PB-240 050

RADIOLOGICAL HEALTH DATA. VOLUME 6, NUMBERS 1-3. JANUARY-MARCH 1965

Public Health Service
Washington, D. C.

March 1965

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NTIS
National Technical Information Service
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BIBLIOGRAPHIC DATA SHEET

1. Report No.
RHD 6 (1-3)

2.

PB 240 050

4. Title and Subtitle
Radiological Health Data
Volume 6, Nos 1-3

5. Report Date
Jan-Mar 1965

6.

7. Author(s)
None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C. 20201

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered
Final: Jan-Mar 1965

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented. in 23 volumes. For prices of individual issues, see below: ←

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

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NATIONAL TECHNICAL
INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

PRICES SUBJECT TO CHANGE

17c. COSATI Field/Group

18. Availability Statement
Release unlimited

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
176

22. Price PC/MF
7.00/2.25

1

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

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JANUARY 1965

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Synopses of contributed articles are presented below in reference card format for the reader's convenience.

JOHNSON, J. E., and G. W. WARD (Colorado State University) *Cesium-137 in milk from dry-lot and pasture-fed cows in Fort Collins, Colorado, during 1963. Radiological Health Data, Vol. 6, January 1965*, pp. 29–30.

Cesium-137 levels in milk followed a pattern that could be identified with different feeding practices used with 2 segments of the Colorado State University herd. Before separating the herd into dry-lot and pasture-fed groups, milk from the eleven high-producing cows (selected for later pasture-feeding) had the same average cesium-137 activity as milk of 80 other cows selected for dry-lot feeding. After putting eleven cows on pasture (from May 1 to September 9, 1963) elevated cesium-137 levels in pasture forage or stored feed contaminated by spring deposition were promptly reflected by milk levels of cesium-137.

BARATTA, E. J., and E. R. WILLIAMS (Division of Radiological Health) *Radionuclide levels in teen-age diets—a comparative study of two sampling programs. Radiological Health Data, Vol. 6, January 1965*, pp. 37–40.

A comparison is made between data obtained from the Consumers Union study and that from the Division of Radiological Health Institutional Total Diet Sampling Network. Discrepancies between the observed strontium-90 to stable calcium and cesium-137 to stable potassium ratios appear to be due to a difference in the amount of food consumed in each study.

JACOBSON, G. A., D. E. VAN FAROWE, J. M. HENNIGAN, and R. C. BENNETT *Michigan Department of Health Reactor Environmental Surveillance Program—A summary report. Radiological Health Data, Vol. 6, January 1965*, pp. 49–60.

Environmental surveillance around the Enrico Fermi Power Reactor and the Big Rock Point Power Reactor has indicated that since the plants became operational, levels of radioactivity in air, rainwater, soil, field mice, and vegetation have reflected only fluctuations in background radiation due to fallout and natural activity. Surveillance operations begain in 1958 at the Enrico Fermi Reactor and in 1960 at the Big Rock Point Reactor.

3

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis for alerting systems to determine when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also compared in beta concentration isograms.

1. Radiation Surveillance Network
September 1964

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators regularly submit their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, SEPTEMBER 1964

Station location		Air surveillance				Precipitation measurements		
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Average concentration (pc/liter)	Total deposition (nc/m²)
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	21	1.10	<0.10	0.54	Aug 64	200	16.0
Alaska:	Adak	23	0.78	<0.10	0.16	Nov 64	[b]	
	Anchorage	30	0.53	<0.10	0.18	Jul 64	200	3.5
	Attu Island	29	0.44	<0.10	0.16	Dec 64		
	Fairbanks	[illegible]	0.37	<0.10	0.16	Aug 64	300	6.7
	Juneau	02	0.13	<0.10	0.10	Sep 64	200	5.5
	Kodiak	24	0.81	<0.10	0.21	Oct 64		
	Nome	13	0.38	<0.10	0.14	Feb 64		
	Point Barrow					Jan 65		
	St. Paul Island	24	0.59	<0.10	0.17	Mar 64		
Ariz:	Phoenix	27	1.16	<0.10	0.42	Sep 64		
Ark:	Little Rock	24	1.16	<0.10	0.38	Sep 64	200	24.3
Calif:	Berkeley	19	0.48	<0.10	0.27	Oct 64		
	Los Angeles	20	0.71	0.22	0.36	Jan 65		
Canal Zone:	Ancon	17	0.10	<0.10	0.10	Nov 64		
Colo:	Denver	26	1.06	0.11	0.41	Oct 64	200	2.8
Conn:	Hartford	27	0.79	<0.10	0.42	Oct 64	210	9.4
Del:	Dover	20	0.94	<0.10	0.57	Aug 64		
D. C:	Washington	29	1.11	<0.10	0.55	Aug 64	230	23.3
Fla:	Jacksonville	26	1.19	0.11	0.54	Sep 64	200	7.9
	Miami	30	1.00	<0.10	0.34	Oct 64	210	10.2
Ga:	Atlanta	13	0.50	0.13	0.32	Jul 64		
Guam:	Agana	30	0.22	<0.10	0.11	Apr 64		
Hawaii:	Honolulu	27	0.43	<0.10	0.20	Dec 64	300	4.1
Idaho:	Boise	28	1.11	0.13	0.45	Dec 64		
Ill:	Springfield	27	1.13	0.14	0.48	Mar 64	220	4.1
Ind:	Indianapolis	29	1.25	<0.10	0.54	Jul 64	240	16.6
Iowa:	Iowa City	28	0.73	<0.10	0.31	Nov 64	200	8.8
Kans:	Topeka	22	0.70	<0.10	0.27	Jul 64	200	13.1
Ky:	Frankfort	30	1.22	<0.10	0.64	Jan 65	400	14.1
La:	New Orleans	27	0.76	<0.10	0.29	Mar 64	210	23.3
Maine:	Augusta	30	0.97	<0.10	0.37	Mar 64	240	12.5
	Presque Isle	25	0.56	<0.10	0.26	Nov 64	280	6.8
Md:	Baltimore	21	1.01	0.13	0.48	Oct 64	250	8.7
	Rockville	08	0.70	<0.10	0.31	Mar 64		
Mass:	Lawrence	29	1.04	<0.10	0.46	Aug 64	240	8.5
	Winchester	26	1.06	<0.10	0.48	Dec 64	300	15.7
Mich:	Lansing	30	1.36	<0.10	0.63	Jan 65	290	14.4
Minn:	Minneapolis	30	0.38	<0.10	0.18	Mar 64	200	23.9
Miss:	Jackson	30	1.07	<0.10	0.56	Apr 64	200	11.7
	Pascagoula	12	1.22	<0.10	0.48	Dec 64		
Mo:	Jefferson City	30	0.83	<0.10	0.30	Jul 64	200	23.0
Mont:	Helena	29	1.33	0.12	0.47	Nov 64	570	3.7
Nebr:	Lincoln	18	1.07	<0.10	0.60	Apr 63		
Nev:	Las Vegas	25	0.68	0.14	0.41	Aug 64		
N. H:	Concord	15	0.94	0.14	0.47	Jan 65		
N. J:	Trenton	28	0.87	<0.10	0.48	Apr 64	210	5.4
N. Mex:	Santa Fe	25	0.54	<0.10	0.21	Nov 64	210	9.8
N. Y:	Albany	18	0.93	0.15	0.53	Jul 64	200	3.1
	Buffalo	14	1.23	0.24	0.59	Nov 64		
	New York	23	0.86	<0.10	0.47	Dec 64		
N. C:	Gastonia	20	0.87	<0.10	0.55	Nov 64	250	4.8
N. Dak:	Bismarck	28	0.86	0.12	0.35	Jan 65	200	3.9
Ohio:	Cincinnati	21	0.98	0.14	0.55	Aug 64		
	Columbus	30	1.30	0.17	0.68	Apr 64	400	18.2
	Painesville	28	1.50	0.22	0.79	Oct 64	230	14.4
Okla:	Oklahoma City	28	0.53	<0.10	0.20	Apr 64		
	Ponca City	30	0.46	<0.10	0.16	Oct 64	200	22.3
Ore:	Portland	30	1.54	<0.10	0.45	Oct 64	210	4.4
Pa:	Harrisburg	26	1.02	0.20	0.61	Jul 64	200	5.9
P. R:	San Juan	26	0.42	<0.10	0.15	Mar 64	200	9.8
R. I:	Providence	29	0.99	<0.10	0.41	Jan 64	230	20.7
S. C:	Columbia	30	0.74	<0.10	0.44	Dec 64	200	4.2
S. Dak:	Pierre	20	0.65	<0.10	0.27	Sep 64		
Tenn:	Nashville	29	1.13	<0.10	0.65	Jan 65	230	19.8
Tex:	Austin	28	0.60	<0.10	0.23	Aug 64	210	20.8
	El Paso	23	0.56	<0.10	0.25	Jan 65	200	3.0
Utah:	Salt Lake City	30	1.01	0.22	0.53	Aug 64	660	2.2
Vt:	Barre	30	0.90	0.14	0.51	Sep 64	230	10.6
Va:	Richmond	29	0.76	<0.10	0.45	Sep 64	220	18.4
Wash:	Seattle	30	0.70	<0.10	0.20	Jul 64	200	7.7
	Spokane	27	1.18	<0.10	0.32	[c]—		
W. Va:	Charleston	26	1.32	<0.10	0.65	Dec 64	200	14.8
Wis:	Madison	30	1.02	<0.10	0.44	Sep 64	220	11.8
Wyo:	Cheyenne	30	0.80	<0.10	0.40	Aug 64	1100	5.8
Network summary		1,877	1.59	<0.10	0.39		260	11.5

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Blank indicates no report received.

[c] Profile scheduled for February 1965.

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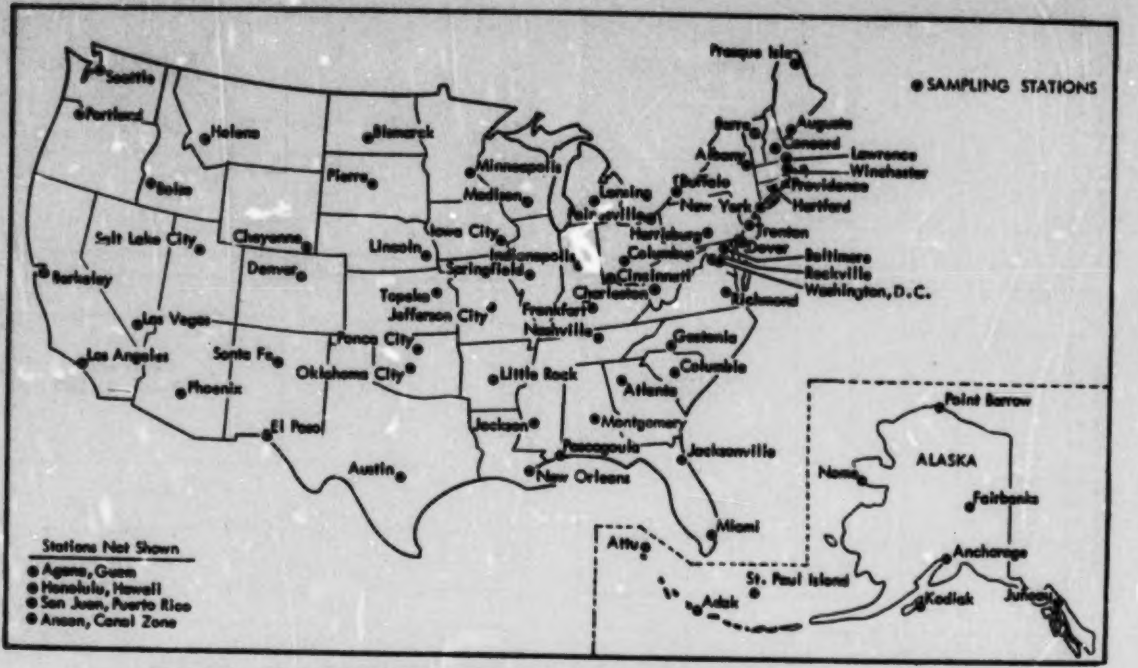
SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Indianapolis
Springfield
Topeka
Jefferson City
Las Vegas
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Phoenix
Little Rock
El Paso
Jackson
Austin
Presque Isle
Augusta
Barre
Concord
Lawrence
Albany
Winchester
Providence
Buffalo
Lansing
Fairsvilles
New York
Hartford
Trenton
Harrisburg
Dover
Columbus
Baltimore
Cincinnati
Rockville
Charleston
Washington, D.C.
Richmond
Frankfort
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Pascagoula
Jacksonville
New Orleans
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*). The September 1964 average gross beta concentrations in air for RSN stations are given in table 1. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The September 1964 average concentrations and total depositions are given in table 1.

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[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value and cannot be used for estimating date of formation.

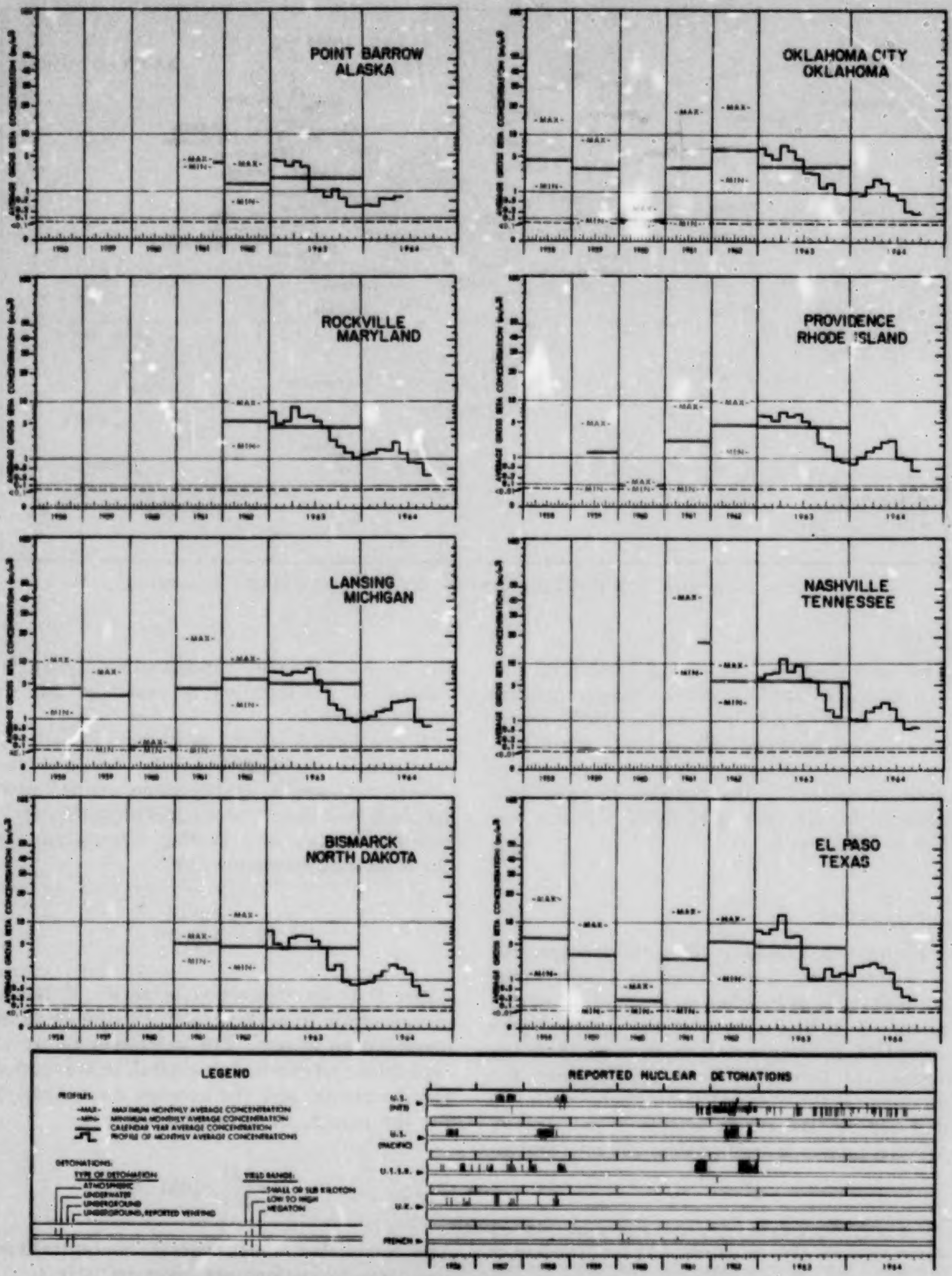

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–SEPTEMBER 1964

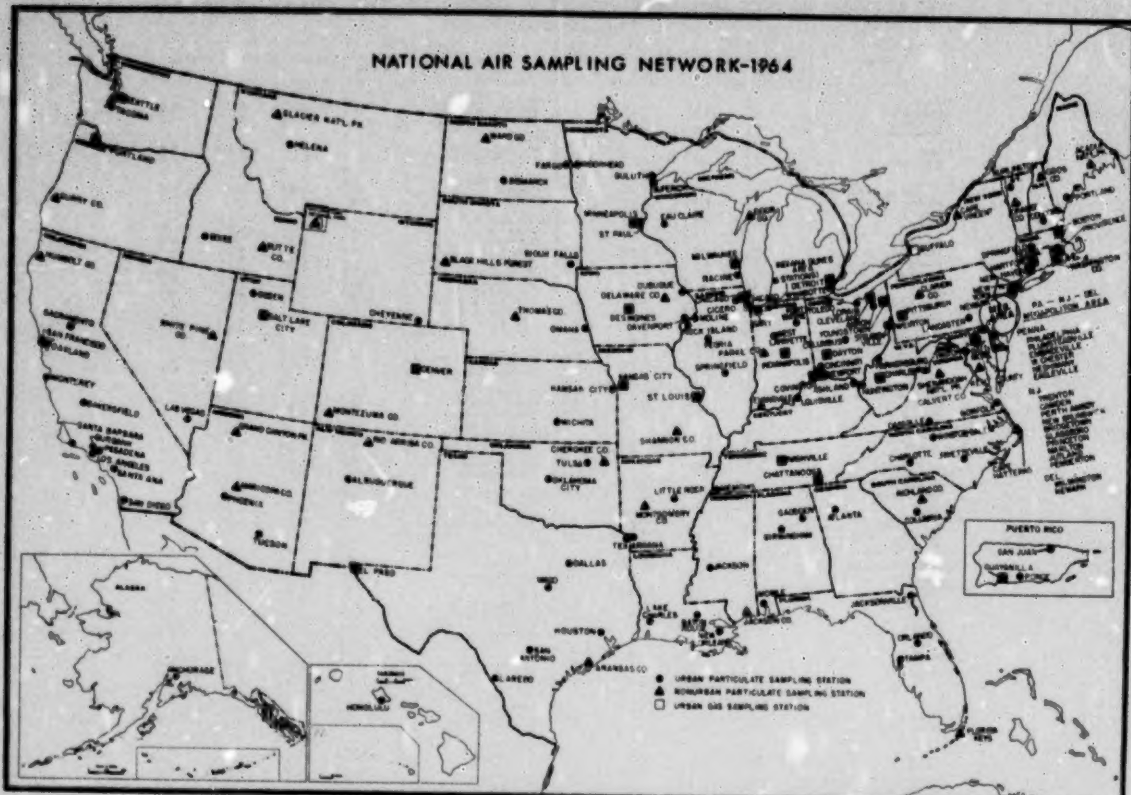
NATIONAL AIR SAMPLING NETWORK-1964
URBAN PARTICULATE SAMPLING STATION
NONURBAN PARTICULATE SAMPLING STATION
URBAN GAS SAMPLING STATION
PUERTO RICO
ALASKA
HONOLULU

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK STATIONS, 1964

2. National Air Sampling Network
Third Quarter 1964

Division of Air Pollution,
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Third quarter 1964 data appear in table 2.

TABLE 2.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, THIRD QUARTER, 1964

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Alabama				
Birmingham	7	1.9	0.1	0.6
Gadsden	7	1.3	0.1	0.7
Mobile	7	1.9	0.2	0.7
Alaska				
Anchorage	7	0.6	0.1	0.3
Arizona				
Grand Canyon Park*	7	1.9	0.2	0.7
Maricopa County*	7	1.2	0.1	0.5
Phoenix	7	1.4	0.1	0.5
Tucson	7	0.9	0.1	0.4
Arkansas				
Little Rock	6	0.6	0.2	0.4
Montgomery County*	6	1.2	0.3	0.7
Texarkana	7	1.4	0.1	0.7
California				
Bakersfield	6	2.1	0.6	1.3
Burbank	3	1.0	0.5	0.7
Humboldt County*	7	0.4	0.1	0.2
Los Angeles	7	0.7	0.3	0.5
Monterey	4	0.4	0.3	0.3
Oakland	7	0.6	0.1	0.3
Pasadena	7	1.9	0.4	0.9
Sacramento	7	0.9	0.3	0.6
San Diego	7	0.6	0.3	0.5
San Francisco	7	0.5	<0.1	0.3
Santa Ana	6	0.9	0.2	0.5
Santa Barbara	7	0.6	0.2	0.4
Colorado				
Denver	7	2.1	0.2	0.9
Montezuma County*	7	0.6	0.2	0.4
Connecticut				
Hartford	7	1.6	0.1	0.7
New Haven	7	1.3	0.1	0.7
Delaware				
Kent County*	6	1.8	0.1	0.7
Newark	5	1.4	0.2	0.7
Wilmington	7	1.0	0.3	0.7
District of Columbia	7	1.9	<0.1	0.5
Florida				
Florida Keys*	4	1.0	0.3	0.6
Jacksonville	7	1.3	0.1	0.7
Orlando	4	1.3	0.3	0.8
Tampa	5	0.9	0.1	0.5
Georgia				
Atlanta	7	1.8	0.2	0.7
Hawaii				
Honolulu	7	1.8	0.3	0.7
Idaho				
Boise	7	3.2	0.5	1.6
Butte County*	6	3.7	0.6	1.7
Illinois				
Chicago	5	0.8	0.3	0.5
Cicero	3	1.2	0.4	0.7
Moline	7	1.2	0.2	0.6
Peoria	6	1.5	0.3	0.7
Rock Island	7	2.4	0.3	1.1
Springfield	7	1.0	0.4	0.7
Indiana				
East Chicago	6	1.0	0.3	0.6
Evansville	6	1.0	0.2	0.5
Fort Wayne	7	2.0	0.3	0.9
Gary	6	1.1	0.4	0.8
Indianapolis	7	1.3	0.4	0.8
Lafayette	6	0.9	0.3	0.5
Parke County*	7	0.6	0.6	0.7
Iowa				
Davenport	7	1.7	0.3	0.8
Delaware County*	7	1.6	0.2	0.7
Des Moines	7	2.4	0.2	0.9
Dubuque	7	1.4	0.1	0.7
Kansas				
Kansas City	7	1.2	0.3	0.6
Wichita	7	1.0	0.3	0.6
Kentucky				
Ashland	3	1.3	0.3	0.8
Covington	7	1.1	0.3	0.7
Louisville	5	0.8	0.2	0.5
Louisiana				
Baton Rouge	6	1.6	0.2	0.6
Lake Charles	7	1.2	<0.1	0.4
New Orleans	7	2.2	0.1	0.7
Maine				
Acadia Nat Park*	6	0.5	0.2	0.3
Portland	6	2.0	0.2	0.9
Maryland				
Baltimore	7	1.7	0.2	0.7
Calvert County*	7	2.1	0.3	0.7
Massachusetts				
Boston	7	1.1	0.2	0.6
Springfield	7	1.5	0.1	0.6
Michigan				
Detroit	6	1.9	0.5	1.0
Wyandotte	6	2.8	0.3	1.2
Minnesota				
Duluth	7	2.3	0.2	0.8
Minneapolis	7	1.6	0.1	0.8
Moorhead	7	1.6	0.3	0.9
St Paul	7	1.8	0.1	0.9
Mississippi				
Jackson	6	1.3	0.3	0.8
Jackson County*	7	2.1	0.1	0.6
Missouri				
Kansas City	7	1.7	0.2	0.8
Shannon County*	6	1.2	0.1	0.6
St Louis	7	1.1	0.4	0.6
Montana				
Glacier Natl. Park*	7	1.0	0.3	0.7
Helena	7	4.7	0.1	1.5
Nebraska				
Omaha	7	2.3	0.1	0.9
Thomas County*	6	1.5	0.4	0.8
Nevada				
Las Vegas	4	2.8	0.2	0.9
White Pine County*	6	3.3	0.4	1.0
New Hampshire				
Concord	7	1.4	0.1	0.6
Coos County*	5	1.0	0.1	0.5
New Jersey				
Bridgeton	6	1.4	<0.1	0.6
Camden	7	1.5	0.4	0.8
Jutland	4	1.4	0.6	0.8
Marlton	6	3.6	0.2	1.1
Newark	7	1.6	0.2	0.7
New Brunswick	7	1.5	0.1	0.7
Pemberton	6	0.7	<0.1	0.5
Perth Amboy	5	1.2	<0.1	0.7
Princeton	5	1.0	0.4	0.7
Trenton	6	1.5	0.1	0.6
Glassboro	7	1.8	0.3	0.6
New Mexico				
Albuquerque	7	0.9	0.1	0.4
Rio Arriba County*	7	0.8	0.3	0.6
New York				
Cape Vincent*	7	2.0	0.2	0.8
New York	6	1.5	0.3	0.8
North Carolina				
Cape Hatteras*	6	2.1	0.1	0.6
Charlotte	7	1.6	0.1	0.5
Fayetteville	6	2.0	0.1	0.6
Winston Salem	6	0.5	0.2	0.3
North Dakota				
Bismarck	7	1.6	0.2	0.9
Fargo	7	2.5	0.3	1.0
Ward County*	7	1.7	0.2	0.7
Ohio				
Akron	7	1.8	0.1	0.9
Cincinnati	6	1.1	0.3	0.7
Cleveland	7	1.7	0.2	0.8
Columbus	7	1.6	0.2	0.7
Dayton	7	1.8	0.4	0.8
Lorain	7	0.9	0.2	0.6
Steubenville	7	1.4	0.1	0.6
Toledo	7	1.5	0.1	0.6
Youngstown	7	2.3	0.1	0.8
Oklahoma				
Cherokee County*	7	0.9	0.2	0.5
Oklahoma City	5	1.0	0.2	0.6
Tulsa	7	1.2	0.1	0.7
Oregon				
Curry County*	5	0.4	0.1	0.2
Portland	6	0.7	0.3	0.4
Pennsylvania				
Clarion County*	5	1.2	0.3	0.6
Embreeville	7	0.8	0.3	0.4
Lancaster	6	2.0	0.1	1.0
Philadelphia	7	1.8	<0.1	0.7
Pittsburgh	7	2.4	0.1	0.8
West Chester	4	1.0	0.2	0.5
Puerto Rico				
Guayanilla	7	0.8	0.1	0.4
Ponce	7	1.0	0.1	0.4
San Juan	7	1.0	0.1	0.4
Rhode Island				
Providence	5	1.2	<0.1	0.7
Washington County*	7	1.3	0.1	0.6
South Carolina				
Columbia	5	2.1	0.4	0.9
Richland County*	6	1.7	0.2	0.6
South Dakota				
Black Hills*	7	1.7	0.4	1.0
Sioux Falls	7	2.0	0.1	0.9
Tennessee				
Chattanooga	6	1.6	0.3	0.8
Memphis	7	1.3	0.1	0.7
Nashville	7	1.1	<0.1	0.7
Texas				
Aransas County*	7	1.0	<0.1	0.4
Dallas	7	1.3	0.1	0.6
El Paso	7	0.6	0.1	0.4
Houston	7	1.3	<0.1	0.3
Laredo	6	0.7	0.1	0.3
San Antonio	7	1.3	0.3	0.5
Texarkana	7	1.2	0.1	0.6
Waco	7	1.4	0.2	0.5
Utah				
Ogden	7	2.5	0.4	1.0
Salt Lake City	6	1.5	0.3	0.8
Vermont				
Burlington	5	1.7	0.3	0.7
Orange County*	7	1.5	0.1	0.7
Virginia				
Danville	7	2.2	0.2	[illegible]
Norfolk	7	2.0	0.2	0.7
Shenandoah Park*	3	1.5	0.3	0.6
Washington				
Seattle	7	0.8	0.1	0.3
Tacoma	7	0.9	0.1	0.3
West Virginia				
Charleston	7	2.1	0.1	[illegible]
Huntington	7	1.4	<0.1	0.7
Parkersburg	7	1.6	0.1	0.7
Weirton	7	2.1	0.2	[illegible]
Wisconsin				
Door County*	5	0.9	0.2	0.5
Eau Claire	7	1.4	0.4	0.8
Milwaukee	6	0.9	0.3	0.6
Racine	7	1.9	0.2	0.7
Superior	7	2.1	0.1	0.7
Wyoming				
Cheyenne	7	1.4	0.4	0.8
Yellowstone Park*	7	1.7	0.3	1.1

* Nonurban Stations

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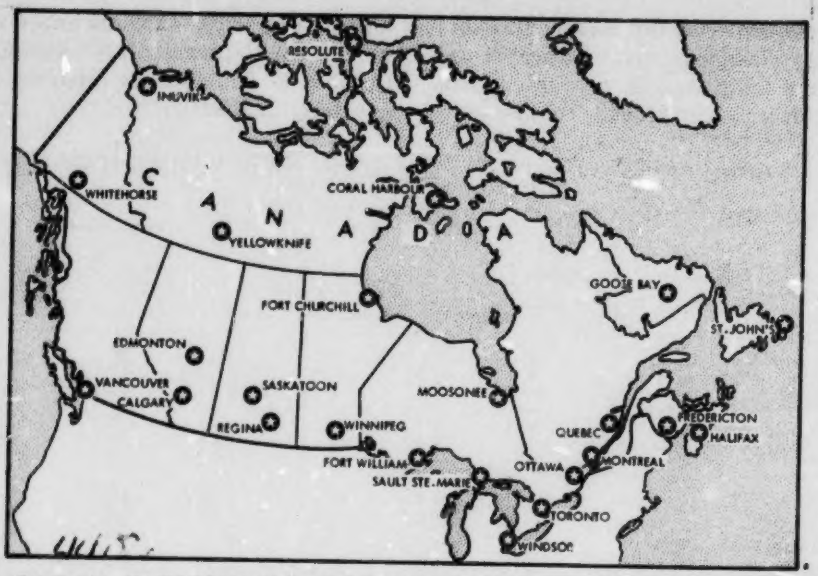

FIGURE 4.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

3. Canadian Air Monitoring Program[2] September 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of the National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for September 1964 are given in table 3 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 6).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450° C.

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[2] Data from *Radiation Protection Programs 10:* 11–24, Radiation Protection Division Canadian Department of National Health and Welfare, Ottawa, Canada (October 1964).

The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for September 1964 samples are given in table 3. Radionuclide analyses are reported quarterly in *RHD*.

TABLE 3.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, SEPTEMBER 1964

Station	Air surveillance				Precipitation data	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	30	1.1	0.1	0.4	186	10.7
Coral Harbour	29	0.9	0.0	0.2	294	8.3
Edmonton	30	1.0	0.1	0.3	172	11.2
Ft. Churchill	29	1.1	0.1	0.3	208	11.9
Ft. William	30	1.1	0.1	0.4	233	14.7
Fredericton	30	0.5	0.1	0.3	90	6.9
Goose Bay	30	1.0	0.1	0.4	226	12.5
Halifax	30	1.0	0.1	0.2	102	11.5
Inuvik	30	0.8	0.1	0.3	234	2.7
Montreal	30	0.8	0.1	0.4	247	8.1
Moosonee	30	0.7	0.1	0.3	213	16.4
Ottawa	30	0.6	0.1	0.4	307	9.0
Quebec	29	0.6	0.1	0.3	206	5.6
Regina	28	0.8	0.1	0.4	188	8.7
Resolute	30	0.6	0.0	0.2	3,752	28.6
St. John's, Nfld	27	0.5	0.1	0.2	111	13.4
Saskatoon	30	0.9	0.1	0.3	395	19.3
Sault Ste. Marie	30	0.9	0.1	0.3	173	15.9
Toronto	30	1.1	0.1	0.4	390	4.2
Vancouver	30	1.1	0.1	0.3	153	18.5
Whitehorse	30	1.0	0.1	0.4	451	6.2
Windsor	22	0.7	0.1	0.4	181	11.5
Winnipeg	30	0.7	0.1	0.4	326	11.5
Yellowknife	30	1.2	0.1	0.3	179	9.5
Network summary	704	1.2	0.1	0.3	378	11.7

4. Mexican Air Monitoring Program September 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the *Comisión Nacional de Energia Nuclear* (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

In 1961 the CNEN appointed its Division of Radiological Protection (DRP) to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 5), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico City while the other four stations are manned by members of the Centra de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radioactiva," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4

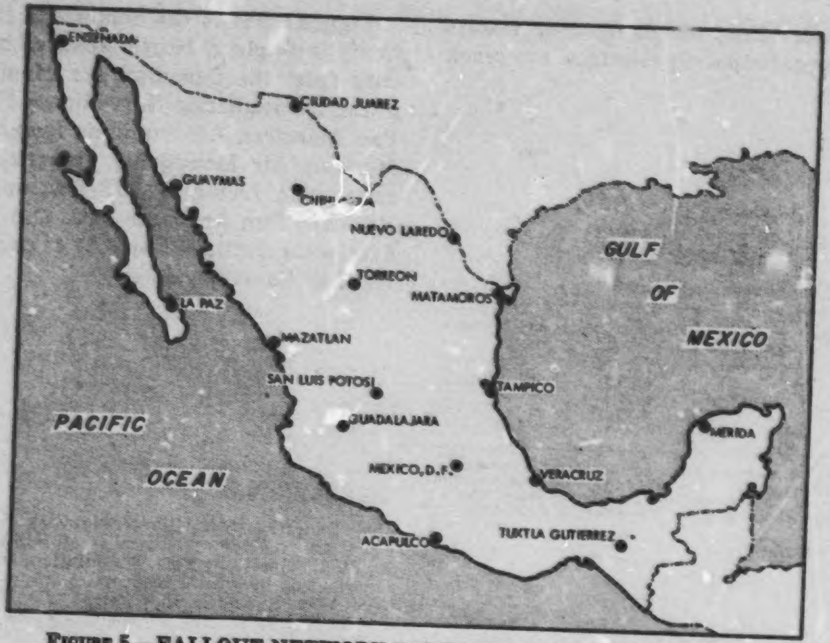

FIGURE 5.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during September 1964 are presented in table 4. The data are also represented in the beta activity isogram map of North America, figure 6.

TABLE 4.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES AT SELECTED SAMPLING LOCATIONS IN MEXICO, SEPTEMBER 1964

Station	Number of Samples	[Concentrations in pc/m³]		
		Maximum	Minimum	Average
Acapulco	3	0.1	0.1	0.1
Ciudad Juárez	21	0.9	0.1	0.2
Chihuahua	21	0.5	0.1	0.2
Ensenada	6	0.4	0.1	0.3
Guadalajara	[a] 1	0	0	0
Guaymas	18	0.7	0.1	0.3
La Paz	10	0.7	0.2	0.4
Matamoros	18	0.2	0.1	0.1
Mazatlán	4	0.2	0.1	0.1
Mérida	18	0.3	0.1	0.1
México, D.F.	19	0.2	0.1	0.1
Nuevo Laredo	11	0.2	0.1	0.1
San Luis Potosí	9	0.2	0.1	0.1
Tampico	12	0.4	0.1	0.1
Torreón	22	0.2	0.1	0.1
Tuxtla Gutiérrez [b]	—	—	—	—
Veracruz	10	0.1	0.1	0.1
Network Summary	203	0.9	0.1	0.2

[a] No analysis made.
[b] Temporarily shut down.

5. Pan American Air Sampling Program September 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

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The September 1964 air monitoring results from the four participating countries are given in table 5.

TABLE 5.—GROSS BETA ACTIVITY IN AIR, SEPTEMBER 1964

[Concentrations in pc/m^3]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	3	0.29	0.17	0.21
Caracas, Venezuela	22	0.39	<0.10	0.11
Lima, Peru	21	0.30	<0.10	0.13
Santiago, Chile	20	0.27	<0.10	0.15

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

6. Gross Beta Activity in Air, North America September 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*13*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*14*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

Figure 6 shows the September 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network, the Pan American Air Sampling Program, and the Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN and Pan American data, and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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(*3*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW–RP–3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

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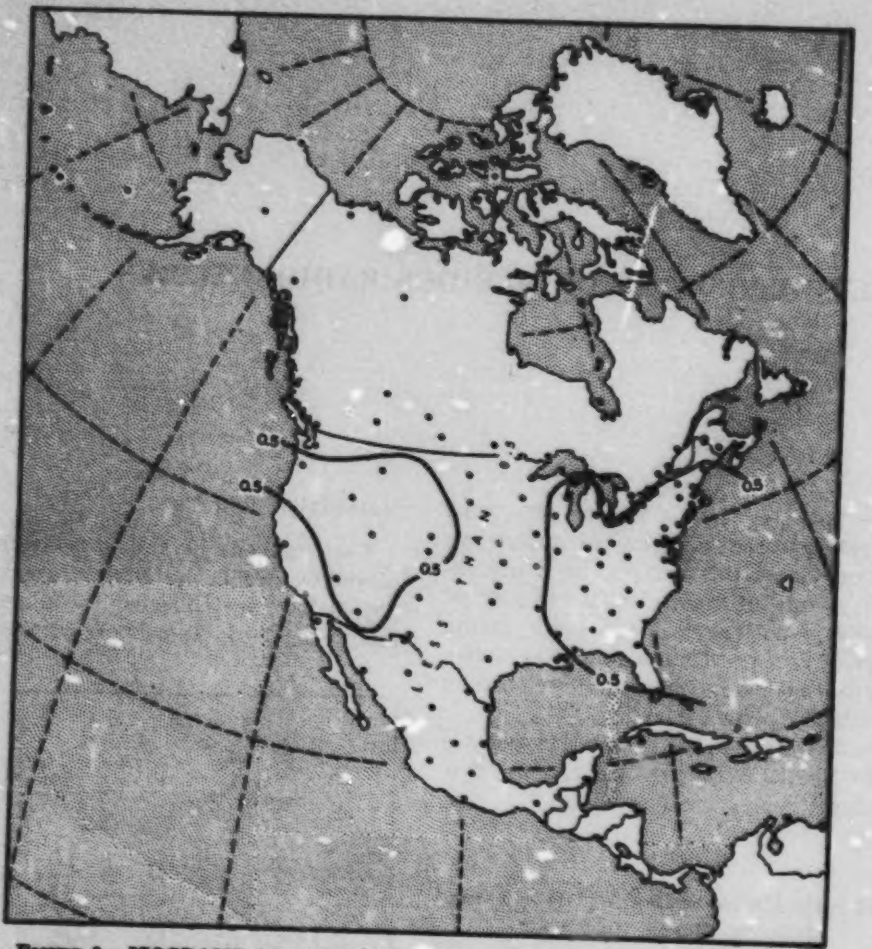

FIGURE 6.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA (pc/m³) SEPTEMBER 1964

(13) Lockhart, L. B., Jr. and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D. C. 20390 (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

(14) Lockhart, L. B., Jr. and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D. C. 20390 (December 1963); summarized in *Radiological Health Data*, January 1964.

MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section the word "fallout" refers to the deposition of radioactive materials on the earth's surface, normally expressed in terms of the activity of selected radionuclides deposited on a unit area during a given period of time. Unless otherwise stated, fallout measurements include both precipitation and dry fallout (settled dust).

Reports of fallout measurements at selected stations in North and South America are presented below.

1. Fallout in the United States and Other Areas,[1] January–March 1964

Health and Safety Laboratory Atomic Energy Commission

Monthly fallout deposition rates are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from 38 of the U. S. stations and 24 other selected points in the Western Hemisphere (see figure 1) covering the period from January through March 1964 are summarized below. All the stations of the 80th Meridian Network, except Washington, D. C., are represented.

Methods of Collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of one month in stainless steel pots with exposed areas

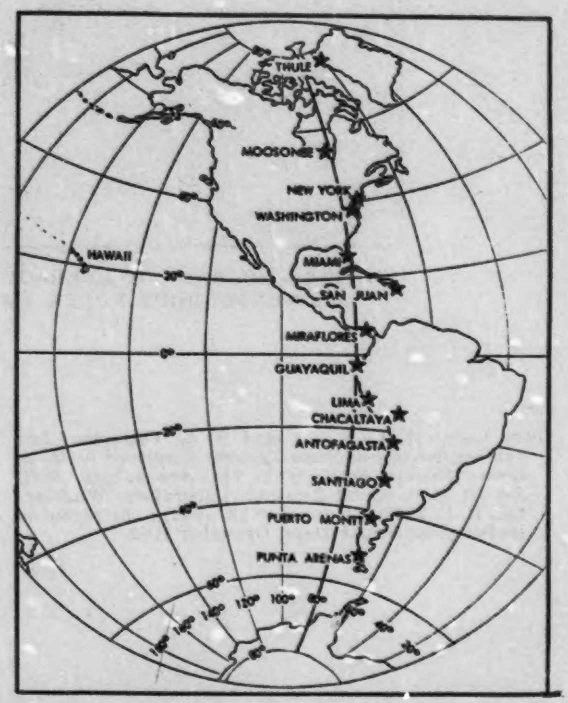

FIGURE 1.—80th MERIDIAN NETWORK SAMPLING STATIONS

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[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL–149*: 1–29, Health and Safety Laboratory, AEC, New York, N.Y. 10014.

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT IN THE UNITED STATES, HASL, JANUARY-MARCH 1964

[Deposition in nc/m²]

Sampling location and type of collection			January	February	March
Ala:	Birmingham	(pot)	0.91	2.39	1.58
Alaska:	Anchorage	(col)	0.16	0.22	0.30
	Barrow	(col)	[a]	[a]	[a]
	Cold Bay	(col)	0.60	0.46	0.51
	Fairbanks	(col)	0.06	0.11	0.07
	Juneau	(col)	0.85	1.57	1.34
	Nome	(col)	[a]	[a]	0.07
Calif:	W. Los Angeles	(pot)	0.20	0.04	0.78
	Palo Alto	(pot)	0.78	0.11	0.46
	Palo Alto	(col)	0.77	0.10	0.40
	San Francisco	(col)	0.72	0.14	0.54
Colo:	Denver	(col)	0.09	0.19	0.22
Fla:	Coral Gables	(pot)	0.75	0.39	0.12
	Miami	(col)	0.19	0.47	0.19
Hawaii:	Hilo	(col)	3.09	3.16	5.22
	Lihue	(col)	1.62	0.15	1.33
	Mauna Loa	(col)	0.12	0.10	0.31
	Oahu	(pot)	0.41	0.69	1.78
Ill:	Argonne	(pot)	0.29	0.13	1.29
La:	New Orleans	(col)	1.96	1.20	1.27
Minn:	International Falls	(col)	0.07	0.17	0.18
Mo:	Columbia	(col)	0.47	0.41	1.30
Mont:	Helena	(col)	0.15	0.17	0.05
N.J:	Westwood	(pot)	1.04	0.42	1.35
	Westwood	(col)	0.53	0.53	1.35
N.Y:	New York	(pot)	1.04	2.10	1.83
N.Dak:	Williston	(col)	0.30	0.02	0.05
Ohio:	Wooster	(pot)	1.11	0.54	1.54
Okla:	Tulsa	(pot)	0.22	[b]	[b]
Ore:	Medford	(col)	0.61	0.19	0.51
S.C:	Columbia	(col)	0.34	1.47	1.70
S.Dak:	Vermillion	(pot)	0.14	0.15	0.60
Texas:	Dallas	(col)	0.51	1.08	1.56
	El Paso	(col)	0.47	0.05	0.69
	Houston	(col)	0.36	1.40	0.54
Utah:	Salt Lake City	(pot)	0.84	0.41	1.78
Va:	Sterling (U.S. Weather Bureau Station)	(col)	[c]1.52	[c]2.04	[c]2.02
Wash:	Seattle	(pot)	1.20	0.81	0.97
	Tatoosh Island	(col)	2.69	1.32	2.17
Wis:	Green Bay	(col)	0.52	0.07	0.52

[a] Not received
[b] No report
[c] Average of 2 collections

of 0.076m². At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with exposed area of 0.07m² attached to an ion exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

Strontium-90

All of the HASL fallout samples—both pot and column—were assayed for strontium-90. The strontium-90 data are given in tables 1 and 2 for 58 selected stations. Where duplicate samples were collected, the average values are given.

Other Radionuclides

Laboratories at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; Appleton, Wisconsin; Palo Alto, California; and Midwest City, Oklahoma, have analyzed monthly pot samples for various radionuclides. The monthly depositon rates for Sr^{89}, Sr^{90}, Ce^{144}, Cs^{137}, Zr^{95}, Mn^{54}, and precipitation depth are presented in table 3.

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TABLE 2.—MONTHLY STRONTIUM-90 FALLOUT IN NORTH AND SOUTH AMERICA, HASL, JANUARY-MARCH 1964

[Deposition in nc/m²]

Station and type of collection			January	February	March
Bermuda:	(Kindley AFB)	(col)	1.13	1.44	0.06
Bolivia:	La Paz	(col)	0.03	0.03	0.03
Brazil:	Belem	(col)	0.18	0.94	0.07
	Trinidade Island	(col)	0.12	0.07	a
Canada:	Ontario, Moosonee [b]	(col)	0.43	0.14	0.10
	Ernest Harmon AB	(col)	0.05	0.37	0.34
	Goose Bay AB	(col)	0.05	0.14	a
Chile:	Antofagasta [b]	(col)	0.03	0.02	0.01
	Puerto Montt [b]	(col)	0.02	0.14	0.16
	Punta Arenas [b]	(col)	0.05	0.09	a
	Santiago [b]	(pot)	0.01	1.10	a
	Santiago	(col)	0.05	0.03	0.04
Colombia:	Bogota	(pot)	0.03	a	a
Costa Rica:	Turrialba	(col)	0.17	0.17	0.11
Equador:	Guayaquil [b]	(col)	0.06	0.08	0.79
	Quito	(col)	a	0.05	0.01
Greenland:	Thule [b]	(col)	0.10	0.05	0.02
Iceland:	Keflavik	(col)	[d]0.38	1.04	0.75
Mexico:	Mexico City	(col)	0.07	a	a
Canal Zone		(col)	0.06	0.17	0.03
Peru:	Lima	(col)	[e]0.04	[e]0.02	a
	Lima [b]	(col)	0.19	0.01	0.02
Puerto Rico:	San Juan	(col)	0.26	0.29	0.41
Venezuela:	Caracas	(col)	[f]0.52	[f]0.04	[f]0.11

[a] Not reported
[b] 80th Meridan Network Station
[c] Not received
[d] (1/11-31)
[e] Mid-month collections
[f] Average of 2 collections

TABLE 3.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPES AT 6 U.S. SITES, HASL, JANUARY-MARCH 1964

Sampling location by State and city	Fission Product and "Tracer" Radionuclides in Monthly Collections (Deposition in nc/m²)																				
	Precipitation (mm)			Strontium-89			Strontium-90			Cerium-144			Cesium-137			Zirconium-95			Manganese-5		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
California, Palo Alto	86.6	6.35	35.3	0.17	0.03	a	0.74	0.10	a	6.52	3.31	6.68	0.90	0.33	0.69	10.5	1.4	0.18	0.90	0.12	0.32
New Jersey, Westwood	88.4	48.0	56.9	0.26	0.07	0.08	1.04	0.42	1.35	22.3	7.14	19.0	2.00	0.95	2.50	1.60	0.42	1.03	2.07	0.49	1.47
Oklahoma, Midwest City	17.0	50.3	34.0	0.03	0.18	a	0.18	1.03	a	2.38	14.6	12.4	0.26	1.72	1.88	4.67	5.33	0.13	0.14	1.09	1.41
Tennessee, Chattanooga	143.0	139.7	289.6	0.35	0.33	0.08	1.29	1.85	1.88	19.8	28.0	36.3	2.02	4.01	4.79	2.12	1.08	b	1.38	2.43	1.94
Washington, Seattle	187.7	31.8	75.4	0.25	0.09	0.04	1.51	0.57	1.41	19.1	7.53	12.6	2.12	0.94	1.87	1.15	0.86	0.66	1.71	0.73	1.38
Wisconsin, Appleton	26.4	4.06	42.2	0.13	0.04	0.13	0.59	0.12	0.82	9.92	2.09	9.65	1.05	0.25	1.50	0.93	0.15	0.61	0.85	0.18	0.91

[a] No report
[b] Lost

FISSION PRODUCT GAMMA ACTIVITY IN SURFACE AIR—80TH MERIDIAN AND U.S. LOCATIONS

Edward P. Hardy, Jr.[1]

80TH MERIDIAN NETWORK
MAY AND JUNE 1964

Fourteen air sampling stations near the 80th Meridian (West) from Thule, Greenland, to Punta Arenas, Chile, make up the Health and Safety Laboratory (HASL) 80th Meridian Network (figure 1). An additional station at Mauna Loa, Hawaii, is included for comparing data with that from Chacaltaya, Bolivia; both are at a high elevation and their respective latitudes north and south are nearly equal.

Air particulates are sampled on 8-inch-diameter polystyrene (Microsorban) filters, drawing air through the filters continuously at the rate of about 1,400 cubic meters per day. Filters are changed on the 1st, 8th, 15th, and 22nd of each month and forwarded to HASL for analysis. A total gamma count over the energy range, 0–3 Mev, is made approximately

TABLE 1.—GAMMA ACTIVITY IN SURFACE AIR 80TH MERIDIAN NETWORK, MAY AND JUNE 1964

[Activity in gamma photons/min/m³]

Station latitude, elevation	May sampling periods				May average	June sampling periods				June average
	1–7	8–14	15–21	22–30		1–7	8–14	15–21	22–30	
Thule, Greenland 77° N, 259 m	0.923	1.02	1.42	0.656	0.972	0.510	0.902	0.351	0.194	0.470
Moosonee, Canada 51° N, 10 m	1.64	0.647	0.938	0.706	0.950	0.663	1.32	0.924	1.39	1.08
New York, N.Y. 41° N, 38 m	2.14	1.83	1.65	1.42	1.54	2.17	1.68	lost	1.11	1.56
Washington, D.C. 39° N, 82 m	1.51	1.76	1.49	1.62	1.60	1.58	1.67	1.34	1.18	1.42
Miami, Fla. 26° N, 4 m	0.724	1.58	1.09	0.889	1.05	0.145	0.829	0.585	0.442	0.495
Mauna Loa, Hawaii 19° N, 3394 m	1.32	1.99	0.770	0.638	1.11	0.372	0.419	0.590	0.488	0.469
San Juan, P.R. 18° N, 10 m	0.856	0.350	0.939	0.604	0.823	0.601	0.594	0.551	0.278	0.488
Miraflores, Canal Zone 9° N, 10 m	0.269	0.717	0.738	0.106	0.419	0.0123	0.0443	0.0659	0.0259	0.0364
Guayaquil, Ecuador 0°–08′ S, 7 m	0.0235	0.0278	0.0370	0.0275	0.0289	0.0358	0.0319	0.0205	0.0199	0.0265
Lima, Peru 12° S, 50 m	0.0464	0.0407	0.0287	0.0408	0.0401	0.0464	0.0543	0.0485	0.0553	0.0513
Chacaltaya, Bolivia 17° S, 5220 m	0.0602	0.0586	0.00493	0.0702	0.0603	0.0812	0.0406	0.0462	0.0770	0.0618
Antofagasta, Chile 24° S, 519 m	0.0459	0.0526	0.0435	0.0407	0.0452	0.0638	0.0475	0.0894	0.0781	0.0696
Santiago, Chile 33° S, 5 m	0.0541	0.0443	0.0530	0.0344	0.0458	0.0312	0.0179	0.0480	0.0244	0.0288
Puerto Montt, Chile 41° S, 5 m	0.0191	0.0430	0.0554	0.0405	0.0396	0.0184	0.0251	0.0174	0.0173	0.0193
Punta Arenas, Chile 53° S, 3 m	0.0505	0.0504	0.0408	0.0411	0.0454	0.0101	0.0141	0.0163	0.0154	0.0141

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[1] Mr. Hardy is a chemist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission.

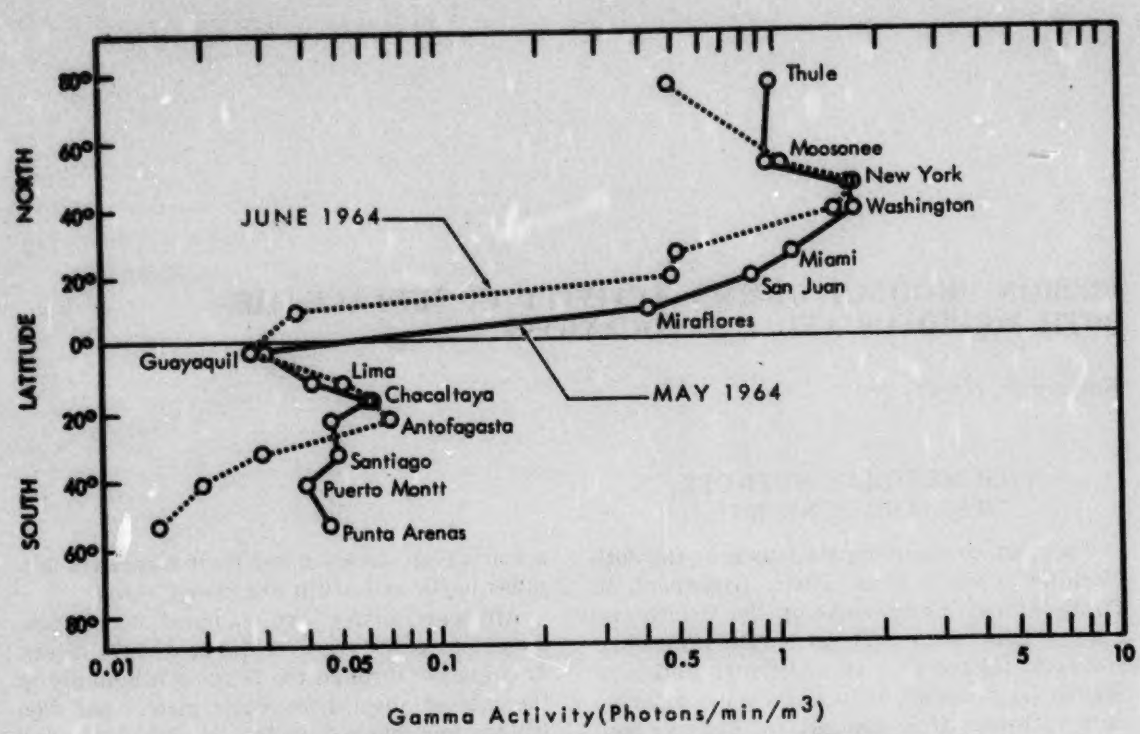

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, MAY AND JUNE 1964

two weeks after the end of the sampling period, using an 8 x 4-inch sodium iodide (thallium-activated) crystal. The filters are then composited on a monthly basis and analyzed radiochemically, together with monthly ground deposition samples taken at the same site, for detectable fission and neutron activation products.

The results of total gamma activity determinations in weekly ground level air filter samples taken at 80th Meridian stations during May and June 1964 are listed in table 1, together with average monthly activity concentrations calculated for each site. The average monthly activities are also plotted in figure 2 as activity-latitude profiles.

The May and June averages for all of the northern sites were 1.1 and 0.75 γ/min/m^3, respectively. The corresponding averages in the Southern Hemisphere were 0.044 and 0.039 γ/min/m^3.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, September 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling Procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that an individual station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after monthly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

Analytical Procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error ᵃ (pc/liter)	Estimated concentration (pc/liter)	Error ᵃ (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	±5	50 or greater	±10
Strontium-90	0 to 20	±2	20 or greater	±10

ᵃ Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for September 1964 (Aug. 30–Sept. 26). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations *versus* radionuclide concentrations in milk, tables 3 and 4 have been prepared using monthly averages.

The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

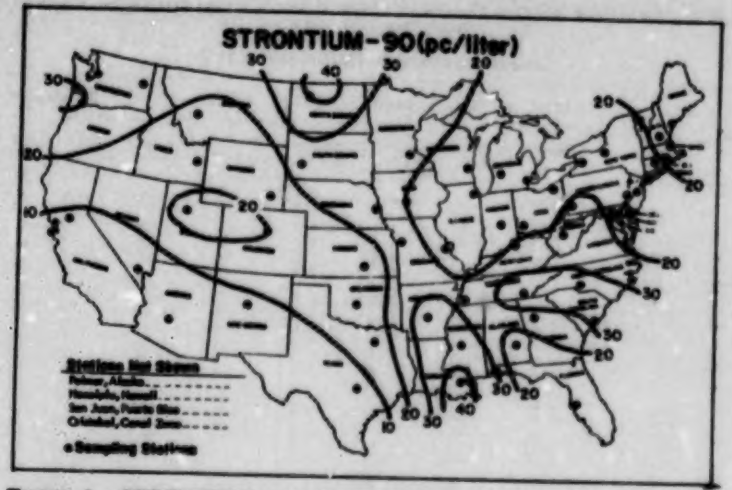
STRONTIUM-90(pc/liter)
30
40
30
20
30
20
10
20
20
20
20
30
30
20
10
20
30
40
30
20
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
• Sampling Stations

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, SEPTEMBER, 1964

method of selection permits graphic presentation of data for each city in the network three times a year. A tabulation of the network monthly maximum, minimum, and average radionuclide concentrations in milk was given for March 1960–March 1964 in the July 1964 *RHD* (*2*).

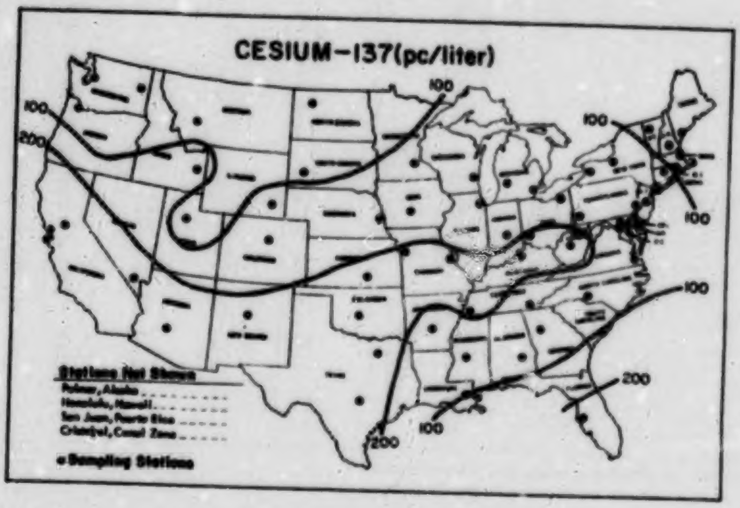
CESIUM-137(pc/liter)
100
100
200
100
100
100
200
100
200
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
• Sampling Stations

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, SEPTEMBER 1964

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, SEPTEMBER 1964 [1]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137	
		Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month
Ala:	Montgomery	1.17	1.16	1.5	1.6	<5	<5	21	19	65	60
Alaska:	Palmer	1.17	1.18	1.5	1.5	<5	5	16	16	105	100
Ariz:	Phoenix	1.15	1.14	1.5	1.6	<5	<5	3	3	25	20
Ark:	Little Rock	1.15	1.16	1.6	1.6	<5	<5	38	34	80	65
Calif:	Sacramento	1.26	1.26	1.5	1.6	<5	<5	6	7	30	30
	San Francisco	1.22	1.28	1.4	1.5	<5	<5	7	4	35	30
C. Z:	Cristobal	1.11	1.12	1.6	1.6	<5	<5	5	6	30	30
Colo:	Denver	1.25	1.30	1.4	1.4	<5	<5	20	20	100	85
Conn:	Hartford	1.10	1.07	1.6	1.6	<5	<5	19	16	110	90
Del:	Wilmington	1.15	1.16	1.5	1.5	<5	<5	20	18	85	65
D. C:	Washington	1.11	1.11	1.6	1.6	<5	<5	19	16	65	55
Fla:	Tampa	1.19	1.20	1.6	1.6	<5	<5	17	18	255	245
Ga:	Atlanta	1.17	1.18	1.5	1.5	<5	<5	28	26	105	90
Hawaii:	Honolulu	1.19	1.20	1.4	1.4	<5	<5	11	8	70	70
Idaho:	Idaho Falls	1.24	1.24	1.4	1.4	<5	<5	25	18	110	85
Ill:	Chicago	1.14	1.15	1.5	1.5	<5	<5	19	14	85	70
Ind:	Indianapolis	1.15	1.12	1.5	1.5	<5	<5	18	15	70	55
Iowa:	Des Moines	1.21	1.20	1.3	1.3	<5	5	22	20	70	65
Kans:	Wichita	1.17	1.18	1.4	1.4	<5	<5	18	17	50	40
Ky:	Louisville	1.13	1.16	1.6	1.6	<5	<5	27	23	30	40
La:	New Orleans	1.19	1.20	1.6	1.5	<5	<5	48	43	115	100
Maine:	Portland	1.14	1.08	1.5	1.5	<5	<5	28	25	175	150
Md:	Baltimore	1.13	1.14	1.5	1.5	<5	<5	21	18	70	55
Mass:	Boston	1.13	1.09	1.5	1.5	<5	<5	31	22	180	140
Mich:	Detroit	1.14	1.16	1.5	1.6	<5	<5	16	13	90	70
	Grand Rapids	1.15	1.11	1.5	1.5	<5	<5	19	15	100	35
Minn:	Minneapolis	1.21	1.22	1.5	1.5	<5	<5	27	22	110	90
Miss:	Jackson	1.21	1.21	1.5	1.5	<5	<5	37	33	85	80
Mo:	Kansas City	1.19	1.20	1.3	1.3	<5	5	20	22	55	50
	St. Louis	1.20	1.19	1.4	1.5	<5	<5	21	16	55	40
Mont:	Helena	1.20	1.19	1.5	1.5	<5	<5	20	15	115	110
Nebr:	Omaha	1.21	1.18	1.4	1.2	<5	<5	24	21	70	60
Nev:	Las Vegas	1.19	1.20	1.4	1.3	<5	<5	6	4	50	45
N. H:	Manchester	1.17	1.18	1.5	1.5	<5	<5	30	26	205	100
N. J:	Trenton	1.12	1.14	1.5	1.5	<5	<5	18	16	85	65
N. Mex:	Albuquerque	1.19	1.20	1.4	1.4	<5	<5	9	8	45	35
N. Y:	Buffalo	1.09	1.10	1.5	1.5	<5	<5	18	15	105	85
	New York	1.09	1.05	1.6	1.6	<5	<5	25	19	120	90
	Syracuse	1.12	1.12	1.5	1.5	<5	<5	15	15	90	80
N. C:	Charlotte	1.17	1.18	1.5	1.5	<5	<5	38	36	100	80
N. Dak:	Minot	1.22	1.26	1.4	1.4	10	10	49	40	145	120
Ohio:	Cincinnati	1.17	1.18	1.6	1.6	<5	<5	19	18	60	45
	Cleveland	1.12	1.13	1.5	1.6	<5	<5	19	16	90	70
Okla:	Oklahoma City	1.12	1.12	1.6	1.6	<5	<5	19	18	50	45
Ore:	Portland	1.24	1.24	1.4	1.4	<5	<5	30	30	165	120
Pa:	Philadelphia	1.11	1.09	1.5	1.5	<5	<5	18	16	80	65
	Pittsburgh	1.14	1.16	1.5	1.6	<5	<5	29	24	120	90
P. R:	San Juan	1.15	1.16	1.6	1.6	<5	<5	12	12	70	65
R. I:	Providence	1.13	1.12	1.5	1.5	<5	<5	23	22	140	115
S. C:	Charleston	1.15	1.14	1.6	1.5	<5	<5	31	31	110	110
S. Dak:	Rapid City	1.19	1.08	1.4	1.4	<5	<5	43	27	125	110
Tenn:	Chattanooga	1.20	1.20	1.6	1.6	<5	<5	39	36	90	75
	Memphis	1.16	1.16	1.6	1.6	<5	<5	28	22	55	45
Tex:	Austin	1.11	1.10	1.5	1.5	<5	<5	7	6	35	45
	Dallas	1.14	1.12	1.6	1.6	<5	<5	17	16	45	40
Utah:	Salt Lake City	1.27	1.21	1.5	1.4	<5	5	25	24	105	140
Vt:	Burlington	1.13	1.18	1.5	1.6	<5	<5	25	20	140	120
Va:	Norfolk	1.13	1.14	1.6	1.6	<5	<5	23	20	75	70
Wash:	Seattle	1.23	1.22	1.4	1.4	5	10	28	22	170	125
	Spokane	1.22	1.17	1.4	1.4	<5	<5	26	24	130	115
W. Va:	Charleston	1.13	1.11	1.5	1.5	<5	<5	24	21	50	35
Wis:	Milwaukee	1.19	1.20	1.6	1.6	<5	<5	14	12	95	80
Wyo:	Laramie	1.18	1.18	1.4	1.4	<5	<5	20	14	105	80
Network average		1.17	1.16	1.5	1.5	<5	<5	22.3	19.3	94	80

[1] Iodine-131 and barium-140 concentration averages all less than 10 pc/liter.

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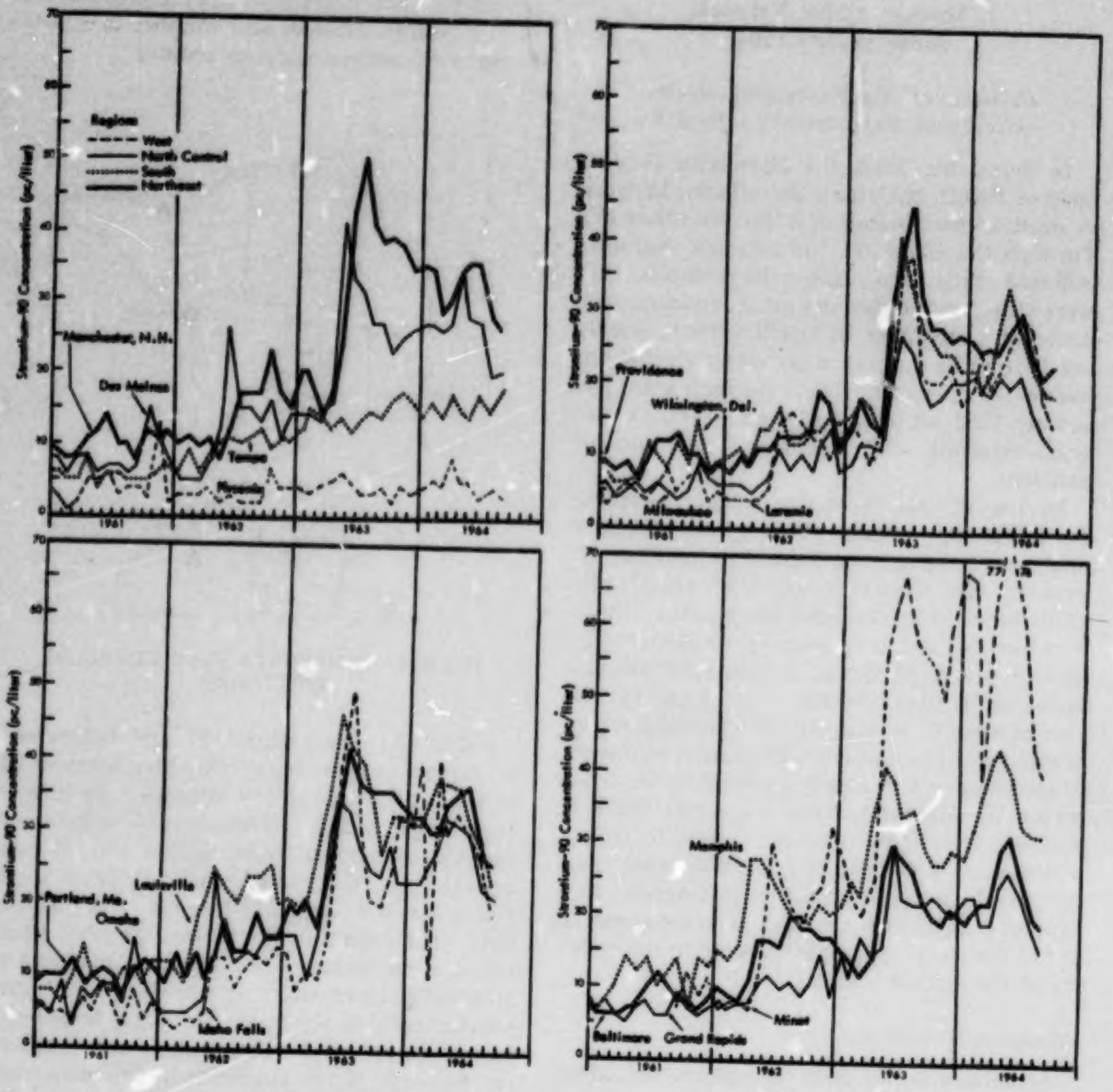

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–SEPTEMBER 1964

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES, FOR STRONTIUM-90, APRIL–SEPTEMBER 1964

Range (pc/liter)	Number of stations in range, 1964					
	Apr.	May	June	July	Aug.	Sept.
Under 10	4	3	4	6	7	8
10–19	12	8	6	6	23	27
20–29	28	20	23	29	23	20
30–39	12	20	17	14	6	6
40–49	2	6	10	4	4	2
50–59	2	4	2	1	0	0
60–69	3	1	0	2	0	0
70–79	0	1	1	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, APRIL–SEPTEMBER 1964

Range (pc/liter)	Number of stations in range, 1964					
	Apr.	May	June	July	Aug.	Sept.
Under 50	2	2	1	4	6	14
50–99	12	16	19	24	30	33
100–149	23	17	24	21	19	13
150–199	17	23	13	8	6	2
200–249	7	3	4	3	1	1
250–299	2	2	2	2	1	0

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2. Minnesota Milk Network, January–June 1964

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a surveillance network to monitor pasteurized milk for strontium-90. Through October 1962, the network operators collected daily two-ounce milk samples that were composited for monthly strontium-90 analyses. Beginning in October 1961, weekly one-liter grab samples were also collected for iodine-131 analyses. Then, beginning in November 1962, an aliquot of each weekly sample was retained for monthly strontium-90 analyses.

In August 1963, the network began sampling for iodine-131, cesium-137, and strontium-90 analyses on the monthly basis now in effect. At present, the network consists of eight milksheds bounded by the same lines as the Minnesota health districts (figure 4). One-liter samples of processed Grade A fluid milk are collected at bottling machines in the pasteurization plants. Thus, samples are generally representative of the market milk in each milkshed. These samples are usually collected in the cities where the Minnesota Health District Office is located. It is sometimes convenient to collect a sample in a district at a location other than that in which the district office is situated. This type of sample is considered as representative of the district as a sample collected in the vicinity of the district office.

Analytical Procedure

Strontium-90 in milk is determined after ashing (450° C.) the evaporated residue from an 800-ml sample. Evaporation is accomplished by means of a steam bath and infrared overhead heating. Calcium and strontium are precipitated as oxalates at a pH of 4 from a nitric acid solution of the ash. The separated oxalates are then decomposed with nitric acid and peroxide, and the resulting solution scavenged with yttrium and barium (as chromate in the presence of ammonium chloride). Yttrium-90 is allowed to ingrow in the presence of stable yttrium carrier and then precipitated under the same conditions prevailing in the scavenging procedure. The yttrium precipitate is converted to the oxalate, filtered, and counted in a low-background anti-coincidence counter.

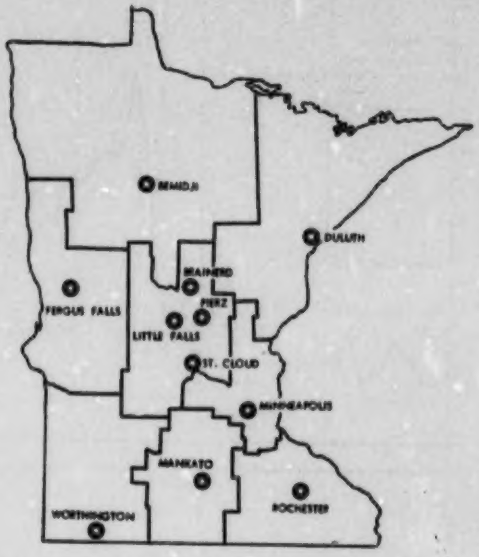

FIGURE 4.—MINNESOTA MILK SAMPLING LOCATIONS

Iodine-131 and cesium-137 are determined by gamma spectrometry. One-liter samples of milk are counted for 100 minutes with a low-background sodium iodide crystal scintillator and multichannel analyzer. Either a 3- x 3-inch crystal and 256-channel analyzer or a 4- x 4-inch crystal and 512-channel analyzer is used. The counts in the iodine-131 photopeak which occur because of background and scatter from other gama-emitting nuclides in milk are subtracted from the total. The value to be subtracted is empirically determined, and is based on the slope of the spectrum in this area and the magnitude of the counts in the channels adjacent to the photopeak. The minimum detectable concentration of iodine-131 in milk is 10 pc/liter.

Results

The monthly strontium-90, iodine-131, and cesium-137 concentrations in milk are given in table 5. These data as well as analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (*3*).

TABLE 5.—RADIONUCLIDES IN MINNESOTA MILK, JANUARY-JUNE 1964 [a]

[Concentrations in pc/liter]

Sampling location (District office)	Strontium-90						Cesium-137					
	January	February	March	April	May	June	January	February	March	April	May	June
Bemidji	42	42	38	43	44	37	270	300	260	300	280	200
Duluth	40	41	42	43	37	60	340	340	340	330	170	320
Fergus Falls	38	19	29	37	30	32	250	270	270	290	270	180
Little Falls	[b] 45	[c] 35	[c] 27	[c] 33	[d] 31	35	[b] 310	[c] 260	[c] 210	[c] 290	[d] 270	[c] 250
Mankato	19	20	22	18	21	20	160	130	190	200	220	160
Minneapolis	30	31	32	33	33	48	290	280	220	280	270	300
Rochester	24	29	22	34	24	28	210	220	220	210	190	130
Worthington	23	12	24	27	26	23	150	170	170	190	165	140
Average	32.6	28.6	29.5	33.5	30.8	35.4	248	246	235	261	229	200

[a] Each monthly iodine-131 concentration at each station was <10 pc/liter during January-June 1964.
[b] Sample collected at Piers.
[c] Sample collected at St. Cloud.
[d] Sample collected at Brainerd.

Recent coverage in *Radiological Health Data:*

Period	Issue
October-December 1961 (Iodine-131 data)	*March 1962*
May-December 1961 (Strontium-90 data)	*August 1962*
March-September 1962	*April 1963*
September 1962-June 1963	*November 1963*
July-December 1963	*June 1964*

3. Canadian Milk Network,[3] September 1964

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 5) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*4*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet

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[3] Data from *Radiation Protection Programs, Vol. 2, No. 10*, 25-29, Radiation Protection Division, Canadian Department of National Health and Welfare (October 1964).

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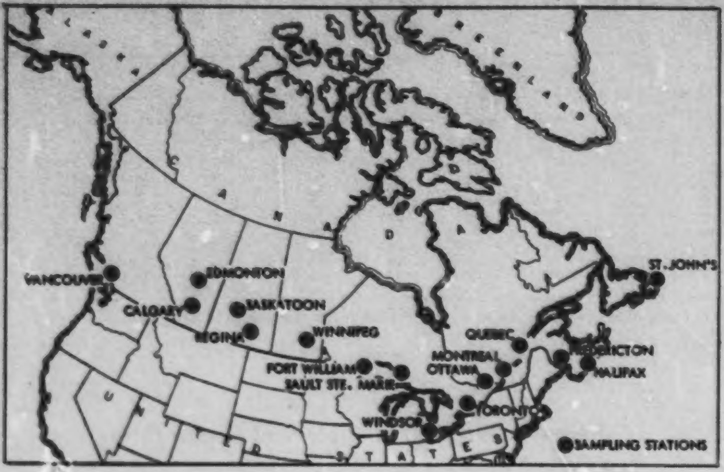

FIGURE 5.—CANADIAN MILK SAMPLING STATIONS

and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450° C., dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 6.

TABLE 6.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±30%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 7 presents monthly averages of strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had <5 pc/liter.

TABLE 7.—RADIONUCLIDES IN CANADIAN WHOLE MILK, SEPTEMBER 1964

[Radionuclide concentration in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.19	1.5	36.4	116
Edmonton	1.15	1.6	30.6	112
Ft. William	1.12	1.6	33.1	193
Fredericton	1.16	1.6	30.0	180
Halifax	1.16	1.6	36.3	159
Montreal	1.13	1.6	25.6	104
Ottawa	1.12	1.6	17.5	98
Quebec	1.13	1.6	35.0	164
Regina	1.13	1.6	30.7	109
St. John's, Nfld	1.11	1.6	61.6	248
Saskatoon	1.17	1.6	37.3	114
Sault Ste. Marie	1.13	1.6	33.7	166
Toronto	1.13	1.6	11.2	71
Vancouver	1.20	1.6	40.5	285
Windsor	1.12	1.6	11.2	54
Winnipeg	1.15	1.6	33.8	180
Average	1.15	1.6	31.8	147

REFERENCES

(1) Public Health Service: Summary of Results from the Raw Milk Sampling Program, June 1957–April 1963, *Radiological Health Data, 4:* 511–23 (October 1963).

(2) Public Health Services: Milk Surveillance, Pasteurized Milk Network, March 1964, *Radiological Health Data, 5:* 309–17 (July 1964).

(3) Minnesota Department of Health and Rural Cooperative Power Association: *Survey of Environmental Radioactivity, January–June 1964*, Minneapolis, Minnesota 55440, pp 30–35.

(4) DasGupta, A. K., and H. G. Green: *A Method for the Radiochemical Determination of Iodine-131 in Milk, RPD-23*, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO DOSE ASSESSMENT, OCTOBER 1963–SEPTEMBER 1964

Division of Radiological Health, Public Health Service

The concentration of specific radionuclides in milk analyzed as part of the pasteurized Milk Network (PMN) is reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to world-wide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes used with discretion may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*3,4*).

Total dietary intake is of prime interest, and since the intake via consumption of milk constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and a 1.0 g daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution, allows time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its halflife of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflects temporal and local deposition patterns (*6*).

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TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK[a, b]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Cesium-137	
		Sept 1963–Aug 1964	Oct 1963–Sept 1964	Sept 1963–Aug 1964	Oct 1963–Sept 1964	Sept 1963–Aug 1964	Oct 1963–Sept 1964
Ala:	Montgomery	5	3	23	23	57	56
Alaska:	Palmer	12	9	25	24	154	149
Ariz:	Phoenix	3	3	4	4	26	25
Ark:	Little Rock	9	5	45	45	141	134
Calif:	Sacramento	3	3	9	9	53	51
	San Francisco	5	4	10	10	60	58
C. Z.	Cristobal	[d]	3	[d]	5	[d]	48
Colo:	Denver	8	6	19	19	93	92
Conn:	Hartford	6	4	23	22	162	156
Del:	Wilmington	5	3	25	24	134	126
D. C:	Washington	6	4	20	19	90	86
Fla:	Tampa	4	3	15	16	245	241
Ga:	Atlanta	8	5	32	32	142	139
Hawaii:	Honolulu	4	4	11	11	82	80
Idaho:	Idaho Falls	14	13	26	28	179	177
Ill:	Chicago	5	4	20	20	121	118
Ind:	Indianapolis	5	4	22	22	102	100
Iowa:	Des Moines	10	8	26	26	96	95
Kans:	Wichita	7	6	21	21	71	68
Ky:	Louisville	10	6	32	32	97	94
La:	New Orleans	9	5	51	51	152	149
Maine:	Portland	8	5	33	32	219	210
Md:	Baltimore	7	5	23	22	107	103
Mass:	Boston	9	5	36	34	247	235
Mich:	Detroit	5	3	20	19	121	117
	Grand Rapids	5	4	22	21	132	127
Minn:	Minneapolis	14	11	34	33	158	154
Miss:	Jackson	9	6	42	42	112	110
Mo:	Kansas City	12	8	29	29	86	85
	St. Louis	9	7	24	23	87	85
Mont:	Helena	10	7	29	28	190	184
Nebr:	Omaha	11	9	27	27	101	90
Nev:	Las Vegas	7	6	11	10	81	78
N. H:	Manchester	8	5	34	33	259	247
N. J:	Trenton	6	4	20	19	123	118
N. Mex:	Albuquerque	4	3	12	11	56	55
N. Y:	Buffalo	6	4	22	21	152	146
	New York	8	5	29	27	176	166
	Syracuse[c]	7	4	22	21	152	145
N. C:	Charlotte	8	5	36	36	119	115
N. Dak:	Minot	16	9	60	58	159	156
Ohio:	Cincinnati	5	4	24	24	96	94
	Cleveland	5	3	22	22	118	115
Okla:	Oklahoma City	6	4	23	23	74	72
Ore:	Portland	12	10	32	32	177	172
Pa:	Philadelphia	4	3	21	21	125	123
	Pittsburgh	6	4	31	30	159	153
P. R:	San Juan	4	3	13	13	74	74
R. I:	Providence	5	3	26	25	175	170
S. C:	Charleston	7	5	31	32	132	130
S. Dak:	Rapid City	15	11	45	43	159	156
Tenn:	Chattanooga	10	6	41	41	128	125
	Memphis	7	5	33	32	77	76
Tex:	Austin	3	3	9	9	44	42
	Dallas	4	3	20	20	70	69
Utah:	Salt Lake City	11	9	27	27	187	185
Vt:	Burlington	7	5	28	27	195	187
Va:	Norfolk	5	4	23	18	98	96
Wash:	Seattle	12	9	29	28	165	159
	Spokane	12	10	30	30	150	148
W. Va:	Charleston	8	5	28	28	89	85
Wis:	Milwaukee	4	3	19	18	136	133
Wyo:	Laramie	11	10	22	22	116	112
Network average		8	5	25.9	25.0	127	122

[a] Annual averages were computed on the basis of 52 weekly averages except as noted.
[b] Annual averages for iodine-131 and barium-140 at each station were <10.
[c] Annual average was computed on the basis of 48 weekly averages. No sample was collected during July 1964.
[d] Annual average not shown for Canal Zone. Station was included in PMN in Oct. 1963.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over considerable periods of time.

REFERENCES

(*1*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents U. S. Government Printing Office, Washington, D. C. 20402 (September 1961). Price 20 cents.

(*2*) National Committee on Radiation Protection: *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, National Bureau of Standards Handbook 69*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (June 5, 1959).

(*3*) Bureau of the Census and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data 4:* 15–17 (January 1963).

(*4*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data*, *4:* 124–7.

(*5*) Federal Radiation Council: *Estimates and Evaluation of Fallout in the United States From Nuclear Weapons Testing Conducted Through 1962, Report No. 4*, Superintendent of Documents, Government Printing Office, Washington D. C. 20402 (May 1963).

(*6*) Federal Radiation Council: *Revised Fallout Estimates for 1964–1965 and Verification of the 1963 Predictions, Report No. 6*, Superintendent of Documents, U.S. Government Printing Office, Washington D. C. 20402 (October 1964).

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[2] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

CESIUM-137 IN MILK FROM DRY-LOT AND PASTURE-FED COWS IN FORT COLLINS, COLORADO, DURING 1963[1]

James E. Johnson and *Gerald M. Ward*[2]

Determinations of Cs^{137} in milk were begun at Colorado State University (C.S.U.) in 1962 as part of a controlled study of the passage of this nuclide through the food chain. All milk samples were collected from cows in the C.S.U. herd. Eleven high-producing Holstein cows were put on pasture May 1, 1963, and taken off September 9, 1963, and are referred to as the "pasture herd." These cows were fed some hay and grain in addition to pasture. Milk samples were collected and composited from this herd every two days during the pasture season. The control group was the remainder of the C.S.U. herd, consisting of about 80 cows of the Holstein, Jersey, Guernsey, and Brown Swiss breeds, which were fed throughout the year in the dry lot. Representative milk samples were collected from this group every two days from May 1 to September 9, 1963, and weekly during the remainder of the year, and are referred to as "bulk milk" samples.

The pasture area consisted of ten acres of irrigated brome grass and alfalfa divided into three sections for rotational grazing. The pasture was flood irrigated four times during the summer.

Milk samples were analyzed for Cs^{137}, I^{131}, and K^{40} in a 5.47-liter Marinelli-type beaker using a 4" by 8" NaI (T1) crystal connected to a 400-channel, pulse height analyzer. The system was calibrated by counting known activities of the three nuclides in the same geometry for determination of a "spectrum stripping" equation.

Figure 1 shows the Cs^{137} levels in milk from the dry-lot herd (bulk milk) and the pasture herd for 1963. Also shown are the levels from a group of the highest milk-producing cows in the herd, milked three times daily (3x), and fed in the dry lot. Superimposed on the graph is the Cs^{137} deposition from precipitation on the pasture expressed in $\mu c/mile^2$ by the vertical bars (scale on right).

The milk from the pasture herd was sampled before the cows were put on pasture, and it was confirmed that the Cs^{137} activity averaged the same as the dry-lot herd. When the pasture herd was put on pasture, the milk levels immediately increased. After seven days, the herd was removed for one day for irrigation of the pasture. The herd was returned to the pasture, and the milk levels decreased with a 5-day half-time attributable to washing of the forage by the irrigation water and/or dilution of the activity present by new pasture growth. The levels increased due to substantial rain on day 137 (May 14) and, in general, the pasture milk levels closely reflected the Cs^{137} deposition by rainfall. During a dry period from day 169 to day 191, milk levels decreased with a 15.4-day half-time with, again, immediate response to subsequent rains.

The bulk milk remained relatively constant during the winter and spring months, during which time the cows were fed the same feed. On June 13 (day 164), when the cows in the dry lot started receiving a small amount (20 lbs. per day) of green-cut alfalfa, their Cs^{137} milk levels (bulk milk) increased. Later, on day 220, first-cutting 1963 hay replaced 1962

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[1] This work was supported by A.E.C. Contract AT(11-1)-1171 with the U.S. Atomic Energy Commission.

[2] Mr. Johnson is Radiation Safety Officer and Mr. Ward is a Junior Animal Scientist, at Colorado State University.

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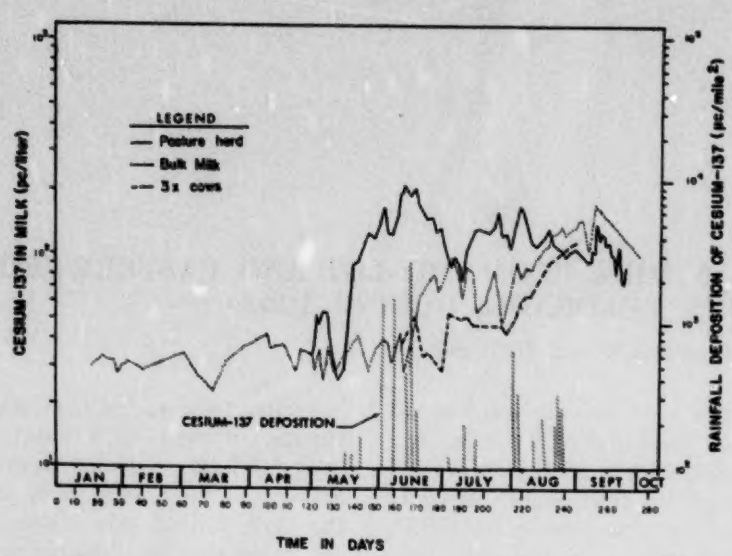

FIGURE 1.—CESIUM-137 CONCENTRATIONS IN MILK FOR PASTURE AND DRY-LOT FED COWS; AND RAINFALL CESIUM-137 DEPOSITION IN 1963

hay, and another increase occurred. The small-scale fluctuations in milk levels can be explained almost exactly by day-to-day differences in the activity of the green-cut alfalfa. The increase in milk activity of the 3x group, starting on day 220, is also explained by a change from third-cutting hay harvested in August 1962 to first-cutting hay harvested in June 1963.

Later in the summer, it is interesting to note that, as the milk from the pasture herd was decreasing in Cs^{137} activity, the levels of milk from the dry-lot herd (bulk milk) exceeded the pasture herd levels. This was probably due to the fact that the first-cutting hay being fed to the dry-lot cows had higher concentrations of Cs^{137} than the pasture forage. On day 251, September 9, the "pasture herd" was taken off pasture and fed the same hay as the dry-lot herd. This produced an immediate increase in the Cs^{137} concentration in the milk of the pasture herd. The cows were then changed to a diet containing only five pounds of hay and 25–40 pounds of grain, which resulted in an abrupt decline. Even though the Cs^{137} in grains is probably more available to the cow than that in hay, the activity per unit weight was much lower and the milk levels decreased with a half-time of 37 days.

Hay and forage samples presently are being analyzed for Cs^{137} to determine the percentage appearing in the milk as influenced by pasture and dry-lot feeding practices.

Conclusions

The data show that milk levels responded rapidly to changes in the activity of the cows' feed and that the activity of pasture forage reached a maximum coincident with heavy spring rains and declined thereafter. The data also illustrate the situation which commonly occurs under farm conditions with cows on pasture. Poor pastures in late summer require the feeding of more hay, which is usually first cutting (late spring harvest) and which will have a much greater Cs^{137} contamination (as well as, presumably, Sr^{90}) than will late summer pasture. Similarly, dry-lot fed cows in late summer or early fall are likely to have greater Cs^{137} levels in their milk than cows which are primarily dependent on pasture because dry-lot fed cows will usually be receiving first cutting hay at this time. This, of course, would not necessarily be true in periods of continued nuclear testing.

RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, APRIL-JUNE, 1964

Division of Radiological Health, Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

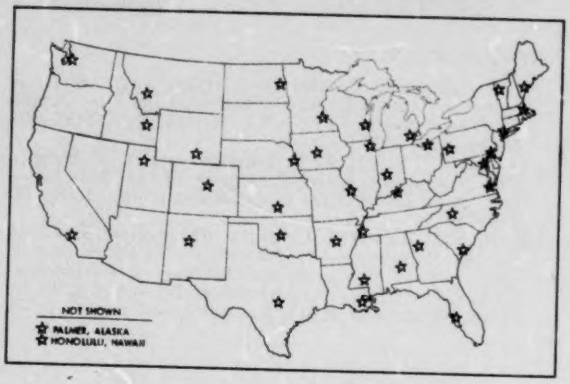

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 41 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (sampling point) except the one at Los Angeles is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

Sampling Procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After collection, the total sample is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The sample for each day is packaged in three parts: (1) solid food and semi-solid foods minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee, and tea. Drinking water is not included in these samples nor reported in this report. A record of the contents of each meal and the approximate amount of each item is made at the institution and sent with the sample.

Analytical Procedures

Because calcium compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium-89 and strontium-90 (*2*), they are included in the analytical program. Total weight is accurately determined in the laboratory. Stable calcium and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy; (2) chemical separation of strontium-89 and strontium-90 with subsequent counting; and (3) radium-226 analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan for iodine-131, cesium-137, and barium-140 are 10 pc/kg. Approximate minimum detectable concentrations for strontium-89, strontium-90, and radium-226 are: 5, 1, and 1 pc/kg, respectively.

Data

Table 1 gives the results of the laboratory analyses of the food samples. In this table are presented concentrations of various radionuclides and stable elements expressed as picocuries per kilogram of diet or grams per kilogram of diet, respectively.

Table 2 presents the dietary intake data expressed on a per-day basis from April through June 1964 for the 41 institutions from which samples were received. The intake values in this table were obtained by multiplying the food consumption rate in kg/day (column 4 of table 2) times the concentration values in grams or picocuries per kilogram of diet given in table 1. Also contained in the table is the range of ages of the children from which samples are being obtained. The reported radionuclide concentrations of these samples are extrapolated to the midpoint of the sample collection period.

Certain of the radioanalyses are reported by the laboratories as being "less-than" (<) a specified value. For data computations, the method employed is to use a zero for <10 pc/kg values for iodine-131 and barium-140. A 2.5 pc/kg was substituted for <5 pc/kg of strontium-89.

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1962	*April 1963*
October–December 1963	*July 1963*
January–March 1963	*September 1963*
April–June 1963	*December 1963*
July–September 1963	*March 1964*
October–December 1963	*July 1964*
January–March 1964	*October 1964*

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TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE (BASED ON A COMPOSITE 7 CONSECUTIVE DAY SAMPLE IN EACH MONTH), SECOND QUARTER 1964

Location of institution	1964	Total weight (kg/day)	Calcium	Potassium	Radium-226 [a,b]	Strontium-89 [b]	Strontium-90	Cesium-137	Barium-140 [b]	Iodine-131 [b]
			(grams per kg.)		(picocuries per kg.)					
Ala., Montgomery	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	2.34	0.6	1.1	[d]NA	<5	14	50	<10	<10
Alaska, Palmer	April	1.50	0.6	1.1	0.8	<5	18	95	<10	<10
	May	1.28	0.7	1.5	0.6	5	27	95	<10	<10
	June	1.10	0.8	1.8	0.1	<5	29	155	<10	<10
Ark., Little Rock	April	2.05	0.8	1.3	*1.6	5	23	85	<10	<10
	May	1.68	0.6	1.2	*2.2	<5	29	115	<10	<10
	June	1.90	0.6	1.3	NA	<5	28	75	<10	<10
Calif., Los Angeles	April	2.01	0.8	1.5	0.5	<5	9	50	<10	10
	May	1.81	0.7	1.6	0.4	<5	7	55	<10	10
	June	1.30	0.6	1.4	0.5	<5	10	50	<10	<10
Colo., Denver	April	2.95	0.7	1.8	0.5	<5	16	80	<10	<10
	May	2.11	0.6	1.6	0.2	<5	13	60	<10	<10
	June	1.61	0.8	1.6	0.4	10	14	65	<10	<10
Del. Wilmington	April	2.11	0.7	1.6	0.6	<5	17	120	<10	<10
	May	1.93	0.8	1.5	0.3	<5	26	145	<10	<10
	June	1.93	0.9	1.6	0.8	<5	17	105	<10	<10
Fla., Tampa	April	2.29	0.5	0.9	*1.5	<5	12	100	<10	<10
	May	2.18	0.6	1.6	*3.0	<5	13	135	<10	<10
	June	2.15	0.5	1.0	NA	<5	9	130	<10	<10
Ga., Atlanta	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	1.68	0.6	1.3	NA	<5	21	75	<10	<10
Hawaii, Honolulu	April	1.79	0.4	1.6	1.0	<5	8	100	<10	<10
	May	[c]NS	NS	NS	NS	11.5	NS	NS	NS	NS
	June	1.52	0.5	1.2	0.5	10	15	65	<10	<10
Idaho, Idaho Falls	April	—	—	—	—	—	—	—	—	—
	May	1.92	0.7	1.5	1.0	<5	40	180	<10	<10
	June	1.85	0.6	2.0	0.5	<5	31	195	<10	<10
Ill., Chicago	April	1.54	0.6	1.5	0.3	<5	15	100	<10	<10
	May	1.36	0.7	1.7	0.3	<5	19	110	<10	<10
	June	1.33	0.7	1.4	0.5	<5	15	90	<10	<10
Ind., Indianapolis	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	1.86	0.8	1.8	0.8	<5	19	80	<10	<10
Iowa, Des Moines	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	2.01	0.8	1.2	NA	<5	19	65	<10	<10
Kans., Wichita	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	2.32	0.7	1.4	NA	<5	14	70	<10	<10
Ky., Louisville	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	1.56	0.7	1.1	NA	<5	33	55	<10	<10
La., New Orleans	April	2.66	1.6	1.6	*2.8	<5	34	110	<10	<10
	May	2.60	0.7	1.5	*7.9	<5	31	115	<10	<10
	June	2.00	0.6	1.2	NA	10	25	85	<10	<10
Maine, Portland	April	2.38	0.7	1.6	0.3	<5	22	140	<10	<10
	May	2.30	0.6	1.5	0.3	<5	20	130	<10	<10
	June	2.17	0.7	1.4	0.2	<5	23	125	<10	<10
Md., Baltimore	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	1.73	0.8	1.6	NA	<5	25	95	<10	<10
Mass., Boston	April	1.76	0.6	1.5	0.3	<5	23	165	<10	<10
	May	2.17	0.6	1.7	0.3	<5	17	150	<10	<10
	June	1.62	0.9	1.7	0.7	<5	33	200	<10	<10
Mich., Detroit	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	2.07	0.8	1.4	0.7	<5	17	95	<10	<10
Minn., Minneapolis	April	1.68	0.5	1.5	0.6	<5	19	100	<10	<10
	May	1.98	0.6	1.4	0.5	25	10	75	<10	<10
	June	1.81	0.5	1.4	1.3	<5	35	95	<10	<10
Miss., Columbia	April	1.90	0.9	1.3	*1.0	<5	38	230	<10	<10
	May	2.04	0.9	1.4	*2.8	5	34	190	<10	<10
	June	1.88	0.9	1.2	NA	<5	33	135	<10	<10
Mo., St. Louis	April	3.24	0.8	1.5	0.4	5	24	70	<10	<10
	May	2.32	0.7	1.5	0.6	<5	22	65	<10	<10
	June	2.42	0.7	1.2	0.4	15	24	55	<10	<10
Mont., Helena	April	2.28	0.6	1.2	0.5	10	15	95	<10	<10
	May	2.05	0.5	1.2	0.4	5	13	100	<10	<10
	June	1.93	0.5	1.3	0.5	5	15	145	<10	<10

TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE (BASED ON A COMPOSITE 7 CONSECUTIVE DAY SAMPLE IN EACH MONTH), SECOND QUARTER 1964—Continued

Location of institution	1964	Total weight (kg/day)	Calcium	Potassium	Radium-226 a b	Strontium-89 b	Strontium-90	Cesium-137	Barium-140 b	Iodine-131 b
			(grams per kg.)		(picocuries per kg.)					
Nebr., Omaha	April	1.69	1.0	1.6	0.6	<5	27	100	<10	<10
	May	2.39	0.9	1.3	1.4	<5	22	125	<10	<10
	June	2.14	0.8	1.5	0.8	<5	20	60	<10	<10
N. Mex., Albuquerque	April	2.03	0.7	1.3	0.6	<5	10	35	<10	<10
	May	1.71	0.9	1.5	0.9	<5	9	40	<10	<10
	June	2.00	0.8	1.3	0.4	5	19	30	<10	<10
N. Y., New York	April	1.55	1.0	1.5	1.2	<5	15	115	<10	<10
	May	—	—	—	—	—	—	—	—	—
	June	—	—	—	—	—	—	—	—	—
N. C., Charlotte	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	2.38	0.7	1.3	NA	<5	27	70	<10	<10
N. D. Fargo	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	1.48	0.5	1.3	1.7	<5	15	130	<10	<10
Ohio, Cleveland	April	2.11	0.5	1.9	0.3	<5	13	100	<10	<10
	May	1.88	0.6	1.4	0.3	<5	13	100	<10	<10
	June	2.14	0.7	1.7	0.5	<5	17	95	<10	<10
Okla., Oklahoma City	April	—	—	—	—	—	—	—	—	—
	May	1.90	0.7	1.6	*2.2	<5	17	65	<10	<10
	June	1.67	0.6	1.0	NA	<5	15	55	<10	<10
Penn., Pittsburgh	April	2.45	0.6	1.6	0.6	<5	14	110	<10	<10
	May	2.25	0.6	1.5	0.8	<5	19	100	<10	<10
	June	2.24	0.6	1.5	1.0	<5	22	100	<10	<10
S. C., Charleston	April	—	—	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—	—	—
	June	1.27	0.5	1.5	NA	<5	16	105	<10	<10
Tenn., Memphis	April	1.42	0.7	1.4	*2.8	<5	29	60	<10	<10
	May	1.41	0.5	1.3	*2.6	<5	24	55	<10	<10
	June	1.52	0.6	1.1	NA	<5	18	50	<10	<10
Texas, Austin	April	1.74	0.5	1.1	*1.0	<5	6	30	<10	<10
	May	2.00	0.4	1.2	*1.6	5	8	50	<10	<10
	June	1.65	0.4	0.9	NA	<5	10	40	<10	<10
Utah, Salt Lake City	April	1.34	0.7	1.5	0.6	5	41	155	<10	<10
	May	1.81	0.9	1.4	0.9	10	27	125	<10	<10
	June	1.20	0.8	1.4	1.6	<5	14	90	<10	<10
Vt., Burlington	April	1.80	0.5	1.5	0.3	<5	14	115	<10	<10
	May	1.42	0.5	1.5	0.4	<5	16	125	<10	<10
	June	1.26	0.6	1.8	0.3	<5	28	140	<10	<10
Va., Norfolk	April	2.21	0.5	1.1	*2.1	<5	16	85	<10	<10
	May	2.08	0.5	1.2	*3.3	<5	15	80	<10	<10
	June	2.23	0.5	1.1	NA	<5	18	75	<10	<10
Wash., Seattle	April	1.99	0.8	1.6	0.6	15	43	90	<10	<10
	May	1.88	0.6	1.3	0.7	20	27	90	<10	<10
	June	1.72	0.8	1.1	0.4	15	25	110	<10	<10
Wis., Milwaukee	April	—	—	—	—	—	—	—	—	—
	May	1.80	0.6	1.6	0.3	<5	15	110	<10	<10
	June	1.87	0.7	1.6	0.7	<5	19	95	<10	<10
Wyo., Laramie	April	2.05	0.6	1.5	0.8	<5	15	90	<10	<10
	May	1.42	0.8	1.4	2.0	<5	18	65	<10	<10
	June	1.67	0.6	1.4	0.5	<5	33	80	<10	<10
Monthly Average	April	2.07	0.6	1.4	0.6	<5	20	100	<10	<10
	May	1.92	0.7	1.4	0.6	<5	20	100	<10	<10
	June	1.83	0.7	1.4	0.7	<5	21	90	<10	<10

[a] Asterisk (*) to the left of number indicates *total radium*.

[b] Average for radium-226; does not include total radium. For averaging purposes "0" was substituted for <10 values for I-131 and Ba-140; 2.5 was substituted for less than 5 values for Sr-89.

[c] Dash (—) indicates station not in operation.

[d] NA indicates no analysis.

[e] NS indicates no sample.

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TABLE 2.—INSTITUTIONAL DAILY DIETARY INTAKE (BASED ON A COMPOSITE 7 CONSECUTIVE DAY SAMPLE IN EACH MONTH), SECOND QUARTER 1964

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium	Potassium	Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium-140	Iodine-131
				(grams per day)		(picocuries per day)					
Ala., Montgomery	April	12-16	[b] —	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		2.34	1.4	2.6	[a] NA	5	33	115	0	0
Alaska, Palmer	April	6-18	1.50	0.9	1.6	1	5	24	140	0	0
	May		1.26	0.9	1.9	1	5	34	120	0	0
	June		1.40	1.1	2.2	0	5	41	215	0	0
Ark., Little Rock	April	6-13	2.05	1.2	2.7	*3.2	5	46	170	0	0
	May		1.68	1.0	2.0	*3.8	5	65	195	0	0
	June		1.90	1.1	2.5	NA	5	53	140	0	0
Calif., Los Angeles	April	12-18	2.01	1.6	3.0	1	5	18	100	0	0
	May		1.81	1.3	2.9	1	5	13	100	0	0
	June		1.30	0.8	1.8	1	5	13	65	0	0
Colo., Denver	April	8-17	2.95	2.1	5.3	1	5	47	235	0	0
	May		2.11	1.3	3.4	0	5	27	125	0	0
	June		1.61	1.3	2.6	1	15	23	105	0	0
Del., Wilmington	April	7-12	2.11	1.5	3.4	1	5	35	250	0	0
	May		1.93	1.4	2.9	0	0	50	280	0	0
	June		1.93	1.7	3.1	2	5	33	205	0	0
Fla., Tampa	April	8-17	2.29	1.2	2.0	*3.5	10	27	230	0	0
	May		2.18	1.3	3.4	*6.6	5	28	300	0	0
	June		2.15	1.1	2.2	NA	5	19	280	0	0
Ga., Atlanta	April	9-15	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		1.68	1.0	2.2	NA	5	35	125	0	0
Hawaii, Honolulu	April	7-15	1.79	0.7	2.9	2	5	14	180	0	0
	May		NS	NS	NS	NS	NS	NS	NS	NS	NS
	June		1.52	0.8	1.8	1	15	23	100	0	0
Idaho, Idaho Falls	April	15-17	—	—	—	—	—	—	—	—	—
	May		1.92	1.3	2.9	2	5	77	345	0	0
	June		1.85	1.1	3.7	1	5	57	360	0	0
Ill., Chicago	April	8-15	1.54	0.9	2.3	1	5	23	155	0	0
	May		1.36	0.9	2.2	0	0	26	150	0	0
	June		1.33	0.9	1.9	1	5	20	120	0	0
Ind., Indianapolis	April	5-12	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		1.86	1.5	3.3	1	5	35	150	0	0
Iowa, Des Moines	April	6-13	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		2.01	1.6	2.4	NA	5	38	130	0	0
Kansas, Wichita	April	10-13	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		2.32	1.6	3.2	NA	5	32	160	0	0
Ky., Louisville	April	14-17	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		1.73	1.2	1.9	NA	5	40	95	0	0
La., New Orleans	April	8-17	2.66	1.7	4.3	*7.3	10	91	290	0	0
	May		2.60	1.7	3.9	*7.8	10	78	295	0	0
	June		2.60	1.6	3.1	NA	25	65	220	0	0
Maine, Portland	April	10-19	2.38	1.6	3.9	1	5	51	330	0	0
	May		2.30	1.4	3.5	1	5	47	305	0	0
	June		2.17	1.5	3.0	0	5	50	270	0	0
Md., Baltimore	April	7-12	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		1.73	1.4	2.8	NA	5	43	165	0	0
Mass., Boston	April	7-14	1.76	1.1	2.7	0	0	41	295	0	0
	May		2.17	1.3	3.6	1	5	38	330	0	0
	June		1.62	1.5	2.8	1	5	53	325	0	0
Mich., Detroit	April	7-15	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		2.07	1.7	2.9	1	5	35	195	0	0
Minn., Minneapolis	April	6-14	1.68	0.8	2.5	1	5	32	170	0	0
	May		1.98	1.2	2.8	1	50	20	150	0	0
	June		1.81	0.9	2.5	2	5	63	170	0	0
Miss., Columbia	April	12-18	1.90	1.7	2.5	*7.7	0	72	440	0	0
	May		2.04	2.0	2.8	*5.8	15	71	385	0	0
	June		1.88	1.7	2.3	NA	5	62	255	0	0
Mo., St. Louis	April	7-15	3.24	2.6	4.9	1	15	78	225	0	0
	May		2.32	1.6	3.5	1	5	51	150	0	0
	June		2.42	1.7	2.9	1	35	58	135	0	0
Mont., Helena	April	7-17	2.28	1.4	2.7	1	25	34	215	0	0
	May		2.05	1.0	2.5	1	10	27	205	0	0
	June		1.93	1.0	2.5	1	10	29	280	0	0

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TABLE 2.—INSTITUTIONAL DAILY DIETARY INTAKE (BASED ON A COMPOSITE 7 CONSECUTIVE DAY SAMPLE IN EACH MONTH), SECOND QUARTER 1964—Continued

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium	Potassium	Radium-226[a]	Strontium-89	Strontium-90	Cesium-137	Barium-140	Iodine-131
				(grams per day)		(picocuries per day)					
Nebraska, Omaha	April	8-17	1.69	1.7	2.7	1	5	37	170	0	0
	May		2.20	2.1	3.0	3	5	50	285	0	0
	June		2.14	1.7	3.2	2	5	43	130	0	0
N. Mex., Albuquerque	April	5-12	2.03	1.4	2.6	1	5	20	70	0	0
	May		1.91	1.7	2.9	2	5	17	75	0	0
	June		2.00	1.6	2.6	1	10	38	60	0	0
N. Y., New York	April	8-18	1.55	1.7	2.3	2	0	24	180	0	0
	May		—	—	—	—	—	—	—	—	—
	June		—	—	—	—	—	—	—	—	—
N. C., Charlotte	April	9-18	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		2.36	1.6	2.9	NA	5	61	160	0	0
N. D., Fargo	April	12-16	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		1.48	0.7	1.9	3	5	22	190	0	0
Ohio, Cleveland	April	6-12	2.11	1.1	4.0	1	5	28	215	0	0
	May		1.88	1.2	2.7	1	5	26	190	0	0
	June		2.14	1.5	3.6	1	5	36	205	0	0
Okla., Oklahoma City	April	17-14	—	—	—	—	—	—	—	—	—
	May		1.90	1.4	3.1	*4.2	10	33	125	0	0
	June		1.67	1.0	1.7	NA	5	25	90	0	0
Penn., Pittsburgh	April	14-16	2.45	1.5	3.9	2	5	35	275	0	0
	May		2.25	1.3	3.4	1	5	44	225	0	0
	June		2.24	1.3	3.4	2	5	40	225	0	0
S. C., Charleston	April	8-14	—	—	—	—	—	—	—	—	—
	May		—	—	—	—	—	—	—	—	—
	June		1.27	0.6	1.9	NA	5	20	135	0	0
Tenn., Memphis	April	13-18	1.42	0.9	2.0	*4.0	10	41	85	0	0
	May		1.41	0.7	1.9	*3.7	5	34	75	0	0
	June		1.52	0.9	1.7	NA	5	27	75	0	0
Texas, Austin	April	13-17	1.74	0.8	1.9	*1.9	5	11	55	0	0
	May		2.00	0.9	2.3	*3.1	5	16	100	0	0
	June		1.65	0.7	1.5	NA	5	16	65	0	0
Utah, Salt Lake City	April	12-18	1.34	0.9	2.0	1	5	55	205	0	0
	May		1.81	1.6	2.5	2	20	49	225	0	0
	June		1.20	1.0	1.7	2	5	17	110	0	0
Vt., Burlington	April	7-[illegible]	1.89	1.0	2.8	1	5	28	220	0	0
	May		1.42	0.7	2.1	1	5	22	180	0	0
	June		1.26	0.8	2.3	0	5	35	175	0	0
Va., Norfolk	April	9-17	2.21	1.1	2.5	*4.5	10	37	140	0	0
	May		2.08	1.1	2.5	*6.9	5	31	175	0	0
	June		2.23	1.1	2.5	NA	5	40	165	0	0
Wash., Seattle	April	12-17	1.99	1.2	3.2	1	30	86	180	0	0
	May		1.88	1.1	2.4	1	40	51	170	0	0
	June		1.72	1.4	1.9	1	25	43	190	0	0
Wis., Milwaukee	April	10-17	—	—	—	—	—	—	—	—	—
	May		1.80	1.1	2.8	1	5	26	200	0	0
	June		1.87	1.3	3.0	1	5	36	180	0	0
Wyo., Laramie	April	11-17	2.05	1.2	3.1	2	5	31	185	0	0
	May		1.42	1.1	2.0	3	5	26	90	0	0
	June		1.67	1.0	2.3	1	5	53	135	0	0
Monthly Average	April		2.02	1.3	3.0	[e]1	5	39	200	0	0
	May		1.92	1.3	2.8	[e]1	10	38	195	0	0
	June		1.84	1.2	2.5	[e]1	10	38	165	0	0

[a] Asterisk (*) to the left of number indicates *total Radium*. Average for radium-226 does not include total radium.
[b] Dash (—) indicates station not in operation.
[c] NA indicates no analysis.
[d] NS indicates no sample.
[e] Average for radium-226; does not include total radium.

RADIONUCLIDE LEVELS IN TEEN-AGE DIETS—A COMPARATIVE STUDY OF TWO SAMPLING PROGRAMS, FEBRUARY-JUNE 1964

Edmond J. Baratta[1] *and Edward R. Williams*[2]

As part of a continuation of previous contract studies, (1–6) the Division of Radiological Health contracted with Consumers Union, Inc., early in 1964 for a study of the levels of strontium–90, cesium–137, stable calcium, and stable potassium in the diets of teenagers in the following ten cities within the United States:

1. New Orleans, Louisiana
2. St. Louis, Missouri
3. Chicago, Illinois
4. Salt Lake City, Utah
5. Los Angeles, California
6. New York, New York
7. Buffalo, New York
8. Bismarck, North Dakota
9. Knoxville, Tennessee
10. Portland, Oregon

The first five of these cities also have institutions participating in the Institutional Total Diet Sampling Network of the Division of Radiological Health. The purpose of this paper is to report the data obtained from samples collected by the Consumers Union study, and to compare these results with similar observations under the Division's Total Diet Network.

Sampling procedure

Dietary samples from the Division's Total Diet Network represent the diet for seven days obtained by duplicating the meals of a different individual each day for varied age groups (*7*). Under the Consumers Union study, a total diet sample was collected from each listed city during February, April, May and June 1964. It consisted of a representative total diet for teenagers (12 to 18 years old) for a full week (21 consecutive meals plus snacks and beverages). The samples were collected for Consumers Union by home economists, who, on the basis of local surveys, prepared meals as nearly identical as possible in composition and weight to the average diet of male teenagers with hearty appetites. When available, fresh produce for the diets was purchased on the local market. Otherwise, frozen and canned items were used. Each daily menu contained exactly five cups of milk and three cups of water. To assure a representative cross section, a variety of brands of each food was bought.

The meals were prepared, including cooking and seasoning, as they would be for actual consumption. Inedible portions of the foods, such as bones, excess fats, skins, shells, pits and cores were discarded. After preparation, the samples from both studies were shipped to the Northeastern Radiological Health Laboratory in Winchester, Massachusetts, for analysis.

To evaluate the contribution of milk to the total radionuclide intake, duplicate samples were collected separately as well as in combination with the other foods in the total diet.

Analytical program and methods

Each sample, including the diet and separate fluid milk portion, was analyzed for strontium–90, cesium–137, stable potassium, and stable calcium. Strontium–90 content was determined by beta-counting the daughter product, yttrium–90, which had been chemically separated from the samples (*8*). Cesium–137 and potassium–40 were determined by gamma spectroscopy, using an expanded matrix solution (*9*). The stable potassium content was estimated from the amount of observed potassium-40. Calcium was determined by titration of oxalate (*10*). For quality control purposes, selected split samples were cross-checked with the Southeastern Radiological Health Laboratory in Montgomery, Alabama. Agreement between the two Laboratories was highly satisfactory.

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[2] Mr. Williams is Laboratory Coordinator, Technical Operations Branch, Division of Radiological Health, Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C.

Observed data

The strontium-90, cesium-137, and stable potassium and calcium contents of each sample, as well as the total weights consumed, are presented in table 1. The daily food consumption ranged from 2.77 to 4.76 kilograms, and stable calcium intakes ranged from 1.6 to 3.0 grams per day. Intake values for strontium-90 ranged from 19 to 101 picocuries per day; the lowest levels were observed in Los Angeles, and the highest in Bismarck. Cesium-137 intake values ranged from 160 to 720 picocuries per day; the lowest levels were observed in Los Angeles, and the highest in Portland.

Comparison of Consumers Union data with Institutional Total Diet results

As mentioned earlier, five of the cities surveyed in the Consumers Union study also serve as sampling locations for the DRH Institutional Total Diet Sampling Network. It should be noted that the latter Network represents actual average diets for a somewhat younger age group having a less hearty diet than that represented in the Consumers Union studies. It may also be observed that the total intake of this group is less.

The data have also been analyzed on the basis of the strontium-90 to stable calcium and of the cesium-137 to stable potassium ratios, which permits a comparison of data independent of the amount consumed. The ratios of strontium-90 to stable calcium for the samples from the five cities common to the two studies are presented in table 2. Similarly, the ratios of cesium-137 to stable potassium are shown in table 3. Average values for these ratios for both the Consumers Union study and the Institutional Diet Network are plotted in figure 1. The strontium-90 data show good agreement except for the February and April samples from St. Louis, and the February sample from Los Angeles. In general, the cesium-137 data show the same order of agreement as the strontium-90 data.

To evaluate milk as a source of stable calcium in the total diets collected under the Consumers Union study, the percentages of calcium contributed to the sampled diets from the milk component have been computed (table 4). Similarly, table 5 presents data on the percentage of strontium-90 contributed to the total diet by the milk component.

TABLE 1.—AVERAGE DAILY TEEN-AGE DIETARY INTAKE,[1] CONSUMERS UNION STUDY, FEBRUARY–JUNE 1964

City	Weight (kg/day)				Calcium (g/day)				Sr-90 (pc/day)				Cs-137 (pc/day)				K (g/day)			
	Feb	Apr	May	June	Feb	Apr	May	June	Feb	Apr	May	June	Feb	Apr	May	June	Feb	Apr	May	June
New York, N. Y.	3.43	4.70	3.57	3.59	2.2	2.6	1.8	2.0	55	61	56	72	280	460	330	420	5.25	7.05	5.07	4.82
Buffalo, N. Y.	3.79	3.97	3.24	3.31	2.1	2.0	1.8	1.9	50	50	46	50	360	380	310	330	5.08	5.60	4.18	3.54
New Orleans, La.	2.91	3.20	3.89	3.09	1.9	2.0	2.1	1.9	67	82	92	85	280	410	370	260	3.20	3.48	4.90	3.55
St. Louis, Mo.	3.91	4.11	3.39	3.64	2.3	2.3	2.0	2.3	52	42	56	67	290	350	270	280	5.38	5.35	4.75	4.00
Chicago, Ill.	3.63	4.33	3.63	3.66	2.4	2.4	1.9	2.2	43	47	4	44	280	370	320	260	4.32	5.80	4.97	4.80
Bismarck, N. D.	3.27	3.64	3.17	2.77	2.2	2.1	2.0	1.6	84	92	101	83	405	440	350	320	4.38	5.27	4.02	3.96
Knoxville, Tenn.	4.24	4.13	3.41	4.37	2.8	2.4	2.3	3.2	66	66	91	97	360	410	410	340	5.34	5.74	5.90	6.03
Salt Lake City, Utah	3.70	4.27	3.43	3.54	2.4	2.4	2.0	2.2	52	55	48	47	460	600	420	490	6.00	6.58	4.15	4.81
Portland, Ore.	4.37	4.37	4.23	4.20	3.0	2.3	2.6	2.3	66	80	83	71	720	700	700	550	7.14	6.47	6.18	5.04
Los Angeles, Calif.	4.76	4.39	4.01	3.89	2.5	2.1	2.3	1.9	28	26	31	19	260	220	260	160	7.66	6.80	6.02	5.41
Average	3.80	4.11	3.60	3.61	2.4	2.3	2.1	2.2	56	61	65	61	370	433	343	334	5.38	5.81	5.02	4.57

[1] Average Based on Seven Days.

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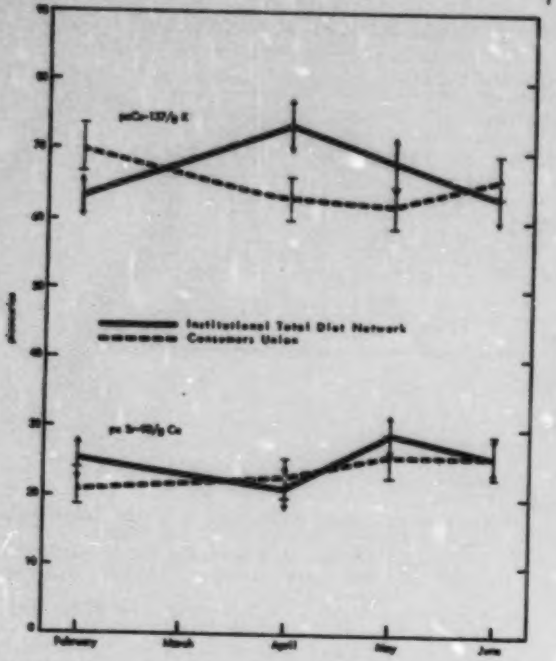

FIGURE 1.—COMPARISON OF AVERAGE RATIOS (pc Cs–137/gK; pc Sr–90/g Ca) IN INSTITUTIONAL TOTAL DIET NETWORK AND CONSUMER'S UNION SAMPLES FOR FIVE CITIES (NEW ORLEANS, ST. LOUIS, CHICAGO, SALT LAKE CITY, AND LOS ANGELES) IN 1964 (Errors at the 95 percent confidence level are approximated by vertical bars)

Discussion

Comparison of the data for 1964 with those observed during previous studies by Consumers Union (*6*) shows that in three cities (Bismarck, Buffalo, and New York) the ratios of strontium–90 to stable calcium during 1964 were at least twice as high as they had been during 1963. The average ratio of strontium–90 to stable calcium in the nine cities included in studies during both 1963 and 1964 showed an increase of 25 percent. The average ratios of cesium–137 to stable potassium in two cities (Los Angeles, and Bismarck) were three times as high in 1964 as in 1963; the average total intake of cesium–137 in the nine cities for 1964 was twice that observed during the same months in 1963.

Though the average total intake for both strontium–90 and cesium–137 increased immediately after February 1964 (table 1), the *rates of increase* in 1964 were much less than in 1963. By June 1964 the average strontium–90 to stable calcium ratio in the diets for the nine cities was no higher than it had been in June 1963. The average total daily intake of cesium–137 in June 1964 was only 60 percent higher than in the corresponding month during 1963.

This study tends to indicate that, for a given city, the ratios of strontium–90 to stable calcium and of cesium–137 to stable potassium were essentially the same for samples obtained through the Consumers Union study and the Institutional Total Diet Network. Therefore, it appears that the differences in daily intakes for radionuclides reported by the two Networks are mainly due to differences in the amounts of food consumed.

TABLE 2.—COMPARISON OF STRONTIUM-90 TO STABLE CALCIUM RATIOS

Sampling site	Sr-90/Ca (pc/gm)									
	February		April		May		June		4 mo. aver.	
	ITDN [1]	CU [2]	ITDN [1]	CU [2]	ITDN [1]	CU [2]	ITDN [1]	CU [2]	ITDN [1]	CU [2]
New Orleans	40.6	34.7	—	41.1	45.9	42.9	40.6	44.4	42.3	40.7
St. Louis	48.2	22.4	30.0	18.1	31.9	28.1	34.1	29.0	36.0	24.4
Chicago	11.3	17.9	23.0	19.3	28.9	21.9	22.2	19.7	21.3	19.7
Salt Lake City	23.3	22.2	25.0	23.0	30.6	24.1	17.0	21.3	23.6	22.6
Los Angeles	4.2	10.9	11.3	12.6	10.0	13.7	16.3	10.0	10.4	11.8
ITDN:	25.5		21.4		29.5		26.0			
CU:		21.6		22.8		26.1		26.0		

[1] Institutional Total Diet Network
[2] Consumers Union

TABLE 3.—COMPARISON OF CESIUM-137 TO STABLE POTASSIUM RATIOS

Sampling site	Cs-137/K ratio (pc/gm)									
	February		April		May		June		4 mo. aver.	
	ITDN [1]	CU [2]	ITDN	CU	ITDN	CU	ITDN	CU	ITDN	CU
New Orleans	86.2	92.5	116.2	67.4	75.4	75.6	72.4	71.0	84.5	76.6
St. Louis	53.8	46.2	66.0	45.9	57.6	42.8	69.9	46.6	61.8	45.3
Chicago	64.3	75.9	64.4	67.4	63.4	67.4	54.7	66.7	61.7	69.3
Salt Lake City	77.2	95.4	91.0	102.5	101.2	90.0	86.6	110.0	89.0	99.4
Los Angeles	33.5	40.9	31.7	33.3	43.1	34.5	30.0	36.1	34.5	36.2
Average ITDN:	63.0	....	73.9	....	66.1	....	62.7			
C:	....	70.2	....	63.3	....	62.1	....	66.1		

[1] Institutional Total Diet Network.
[2] Consumers Union.

TABLE 4.—PERCENT OF CALCIUM INTAKE CONTRIBUTED BY MILK, CONSUMERS UNION STUDY

Sampling Site	February	April	May	June
New York	67	54	89	65
Buffalo	67	70	78	68
New Orleans	79	75	71	74
St. Louis	61	61	70	61
Chicago	58	56	74	59
Bismarck	64	67	70	88
Knoxville	57	58	61	41
Salt Lake City	63	58	70	59
Portland	53	65	56	61
Los Angeles	56	67	57	68
Average	62	63	70	64

TABLE 5.—PERCENT OF STRONTIUM-90 INTAKE CONTRIBUTED BY MILK, CONSUMERS UNION STUDY

Sampling Site	February	April	May	June
New York	45	44	66	50
Buffalo	46	37	48	66
New Orleans	* 1.01	80	80	73
St. Louis	46	64	60	64
Chicago	63	32	69	57
Bismarck	74	57	79	* 1.05
Knoxville	53	74	74	45
Salt Lake City	62	60	71	66
Portland	45	59	76	66
Los Angeles	25	46	29	32
Average	56	55	65	62

* Under ideal conditions, these values should not have exceeded unity—the condition where fluid milk serves as essentially the sole source of Sr-90 in the diet. These higher values undoubtedly are the result of analytical errors and the fact that the total diets and milk components were sampled and analyzed separately.

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JULY 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 131 stations as of December 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–7*).

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on either monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at all newly established stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Strontium–90 analyses are performed on total solids of three-month composites of the weekly samples. The most recent strontium–90 results are presented in the December 1964 issue of *RHD*.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a mem-

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brane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counter.

Results

Table I presents July 1964 results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pc/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1, which gives the June 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the years 1957–1962 have been summarized by Weaver *et al* (*9*). Floyd and Weaver summarized the strontium-90 results obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*10*).

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, JULY 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa.						
Animas River:						
Cedar Hill, N. Mex.	<1	14	14	<1	5	5
Apalachicola River:						
Chattahoochee, Fla.	2	13	15	0	0	0
Arkansas River:						
Coolidge, Kansas	7	30	37	1	14	15
Ponca City, Okla.	39	40	79	1	0	1
Atchafalaya River:						
Morgan City, La.	36	21	57	7	2	9
Bear River:						
Preston, Idaho	6	22	28	1	4	5
Big Horn River:						
Hardin, Mont.	43	22	65	11	7	18
Chena River:						
Fairbanks, Alaska	4	12	16	0	1	1
Clinch River:						
Clinton, Tenn.	1	9	10	0	0	0
Kingston, Tenn.	11	39	50	0	5	5
Colorado River:						
Loma, Colo.	10	20	30	1	9	10
Page, Ariz.	12	52	64	2	11	13
Parker Dam, Calif-Ariz.	2	18	20	0	5	5
Columbia River:						
Wenatchee, Wash.	2	8	10	0	0	0
Pasco, Wash.	22	116	138	0	<1	<1
Clatskanie, Ore.	31	69	100	<1	<1	<1
Connecticut River:						
Enfield Dam, Conn.	6	14	20	0	0	0
Delaware River:						
Philadelphia, Pa.	5	15	20	0	1	1
Great Lakes:						
Duluth, Minn.	2	9	11	0	0	0
Illinois River:						
Grafton, Ill.	7	21	28	1	3	4
Kansas River:						
De Soto, Kans.	52	34	86	5	0	5
Maumee River:						
Toledo, Ohio	1	21	22	0	1	1
Mississippi River:						
St. Paul, Minn.	3	32	35	0	3	3
E. St. Louis, Ill.	40	28	68	11	1	12
New Roads, La.	50	47	97	6	3	9
New Orleans, La.	19	21	40	4	2	6
Missouri River:						
Williston, N. Dak.	8	16	24	2	2	4
St. Joseph, Mo.	116	36	152	30	3	33
North Platte River:						
Henry, Nebr.	13	38	51	1	15	16
Ohio River:						
Toronto, Ohio	1	14	15	0	0	0
Cairo, Ill.	8	17	25	1	1	2
Platte River:						
Plattsmouth, Nebr.	83	31	114	9	4	13
Potomac River:						
Washington, D.C.	3	12	15	0	0	0
Red River, North:						
Grand Forks, N. Dak.	11	53	64	0	4	4
Red River, South:						
Alexandria, La.	7	40	47	1	0	1
Rio Grande River:						
El Paso, Tex.	55	29	84	11	3	14
Laredo, Tex.	18	38	56	3	4	7
San Joaquin River:						
Vernalis, Calif.	9	16	25	2	8	10
San Juan River:						
Shiprock, N. Mex.	170	24	194	28	5	33
Savannah River:						
Port Wentworth, Ga.	6	18	24	<1	0	<1
Snake River:						
Wawawai, Wash.	5	8	13	1	0	1
South Platte River:						
Julesburg, Colo.	5	77	82	0	26	26
Yellowstone River:						
Sidney, Mont.	80	16	96	13	2	15
Maximum	170	116	194	30	14	33
Minimum	<1	8	10	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report (7).

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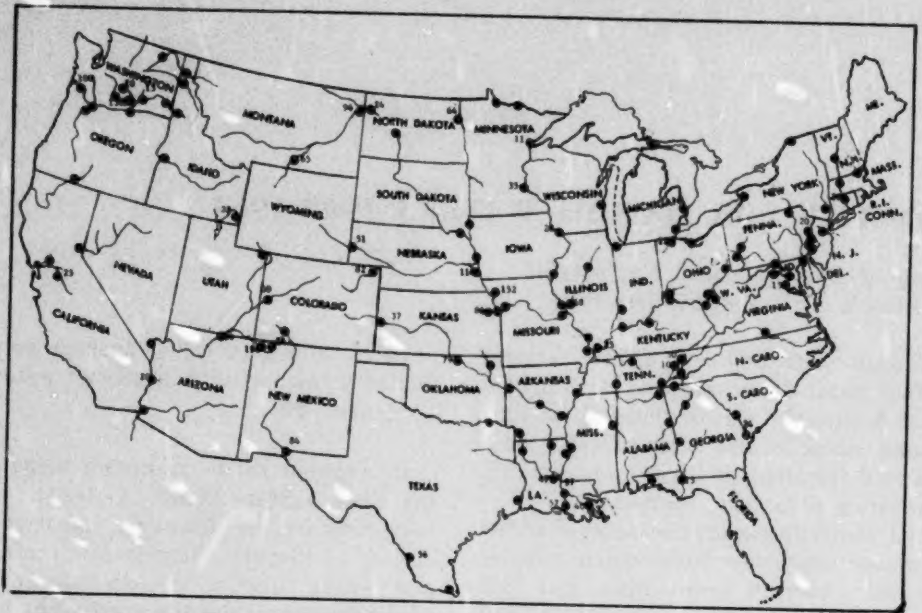
WASHINGTON
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OREGON
IDAHO
MONTANA
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NORTH DAKOTA
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SOUTH DAKOTA
WYOMING
NEBRASKA
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NEVADA
UTAH
COLORADO
82
KANSAS
37
23
CALIFORNIA
ARIZONA
NEW MEXICO
84
TEXAS
36
OKLAHOMA
MINNESOTA
11
WISCONSIN
33
MICHIGAN
IOWA
ILLINOIS
IND.
OHIO
132
MISSOURI
KENTUCKY
ARKANSAS
TENN.
MISS.
ALABAMA
GEORGIA
LA.
FLORIDA
N. CARO.
S. CARO.
VIRGINIA
W. VA.
PENNA.
20
NEW YORK
N. J.
DEL.
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CONN.

FIGURE 1.—SAMPLING LOCATIONS AND TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, JULY 1964

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter at only one station, the Pasco, Washington station on the Columbia River.

The dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water, ranged from zero to 14 pc/liter. Of all stations, four stations, each on a different river, had monthly average dissolved alpha activity greater than 10 pc/liter.

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*11*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pc/liter (*12*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington D. C. 20402. Price $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

(*4*) *Ibid.*, 1961 Edition.[2]

(*5*) *Ibid.*, 1962 Edition.[2]

(*6*) *Ibid.*, 1963 Edition (in press).

(*7*) *Ibid.*, 1964 Edition (to be published).

(*8*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(*9*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957–1962, *Radiological Health Data, 4:* 306–16, (June 1963).

(*10*) Floyd, E. P. and L. Weaver: Trends of Strontium-90 Levels in Surface Waters of the United States, 1959–1963, *Radiological Health Data 5:* 390–94 (August 1964).

(*11*) Straub, C. T.: Significance of Radioactivity Data, *Journal of the American Water Works Association, 53:* 704 (June 1961).

(*12*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

RADIOACTIVITY IN FLORIDA WATERS, 1962-1963[1]

Bureau of Environmental Engineering
Florida State Board of Health

The Florida State Board of Health samples raw surface water from locations in 13 hydrological sub-basins. In nine of these sub-basins, raw ground water is also sampled. The samples, analyzed for alpha and beta radioactivity, are collected on a variable frequency.

Figure 1 shows the approximate area of the surface water sub-basins from which samples are obtained. Average gross alpha and beta radioactivity in raw surface water during 1962 and 1963 are presented in table 1. For comparison, table 2 gives the average gross alpha and beta radioactivity in ground water during 1962 and 1963.

In addition to the sampling being done by the Florida State Board of Health, the Sanitary Engineering Research Laboratory, University of Florida, samples raw surface water and water supplies in Alachua County and analyzes the samples for gross alpha and gross beta radioactivity. Samples are taken monthly from each sampling point with the exception of the City of Gainesville's raw water, which is sampled daily. Data are summarized in table 3 as quarterly and yearly averages.

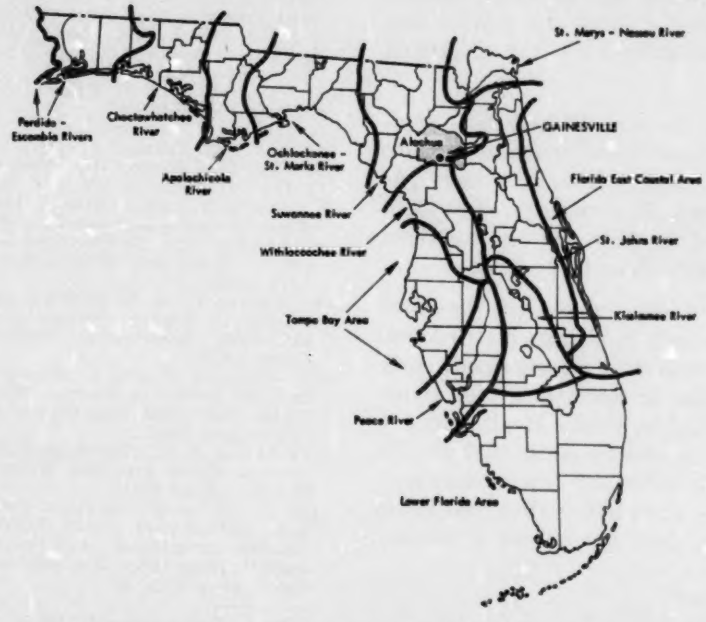
St. Marys - Nassau River
Perdido - Escambia Rivers
Choctawhatchee River
GAINESVILLE
Alachua
Ochlockonee - St. Marks River
Apalachicola River
Florida East Coastal Area
Suwannee River
St. Johns River
Withlacoochee River
Kissimmee River
Tampa Bay Area
Peace River
Lower Florida Area

FIGURE 1.—HYDROLOGICAL SURFACE WATER SUB-BASINS IN FLORIDA

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[1] Data taken from "Report of Florida Radiological Data, Environmental Monitoring Programs, 1962" and "*Ibid*, 1963." Florida State Board of Health, Bureau of Preventable Diseases, Division of Radiological and Occupational Health, Jacksonville, Florida.

TABLE 1.—GROSS ALPHA AND BETA RADIOACTIVITY IN RAW SURFACE WATER IN FLORIDA, 1962-1963

[Contrations in pc/liter]

Sub-Basin	Quarter 1962								1962 average	
	First		Second		Third		Fourth			
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Apalachicola River	5.0 (6)	63.5 (6)			0.3 (7)	15.4 (7)			2.5 (13)	37.6 (13)
Choctawhatchee River	5.2 (7)	63.0 (7)	--------	--------	0.4 (9)	25.3 (9)	--------	--------	2.5 (16)	41.8 (16)
Florida East Coastal Area	--------	--------	2.2 (1)	17.9 (1)	--------	--------	--------	--------	2.2 (1)	17.9 (1)
Kissimmee River	5.1 (1)	10.0 (1)	--------	--------	0.3 (2)	39.7 (2)	Bkg. (2)	28.8 (2)	1.1 (5)	29.4 (5)
Lower Florida Area	2.3 (6)	29.1 (6)	--------	--------	--------	--------	0.2 (15)	36.6 (15)	0.8 (21)	34.5 (21)
Ochlockonee—St. Marks River	0.2 (8)	25.2 (8)	--------	--------	--------	--------	0.2 (19)	12.4 (19)	0.2 (27)	16.2 (27)
Peace River	--------	--------	--------	--------	--------	--------	0.1 (6)	21.9 (6)	0.1 (6)	21.9 (6)
Perdido—Escambia River	7.7 (6)	105.5 (6)	--------	--------	3.0 (8)	44.8 (8)	--------	--------	5.0 (14)	70.8 (14)
St. Johns River	1.0 (1)	23.5 (1)	2.5 (1)	32.8 (1)	0.1 (2)	28.4 (2)	0.1 (3)	54.3 (3)	0.6 (7)	39.4 (7)
St. Marys—Nassau River	--------	--------	--------	--------	--------	--------	Bkg. (2)	52.7 (2)	Bkg. (2)	52.7 (2)
Tampa Bay Area	--------	--------	--------	--------	--------	--------	0.2 (12)	29.4 (12)	0.2 (12)	29.4 (12)
Withlacoochee and Wacassassa Rivers	--------	--------	--------	--------	--------	--------	0.2 (2)	20.3 (2)	0.2 (2)	20.3 (2)
Average	3.8 (35)	53.3 (35)	2.4 (2)	25.4 (2)	1.1 (28)	29.6 (28)	0.2 (61)	26.8 (61)	1.4 (126)	34.8 (126)

Sub-Basin	Quarter 1963								1963 average	
	First		Second		Third		Fourth			
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha'	Beta	Alpha	Beta
Apalachicola River	--------	--------	0.1 (6)	29.9 (6)	0.4 (4)	38.4 (4)	--------	--------	0.2 (10)	33.3 (10)
Choctawhatchee River	0.1 (9)	25.5 (9)	--------	--------	Bkg. (5)	28.2 (5)	0.5 (3)	37.5 (3)	0.1 (17)	28.4 (17)
Florida East Coastal Area	--------	--------	0.2 (2)	120.0 (2)	--------	--------	Bkg. (1)	10.5 (1)	0.1 (3)	83.5 (3)
Kissimmee River	--------	--------	0.2 (3)	100.8 (3)	1.9 (1)	198.4 (1)	0.2 (3)	45.4 (3)	0.4 (7)	94.9 (7)
Lower Florida Area	--------	--------	0.2 (9)	62.4 (9)	0.4 (6)	86.1 (6)	0.6 (1)	87.9 (1)	0.3 (16)	72.9 (16)
Ochlockonee—St. Marks River	Bkg. (21)	73.6 (21)	0.2 (6)	82.8 (6)	0.5 (12)	62.0 (12)	--------	--------	0.2 (39)	71.4 (39)
Peace River	--------	--------	0.2 (6)	138.7 (6)	0.6 (1)	95.3 (1)	0.3 (2)	48.1 (2)	0.3 (9)	113.7 (9)
Perdido—Escambia River	Bkg. (7)	38.4 (7)	Bkg. (1)	27.8 (1)	0.2 (4)	44.7 (4)	0.4 (2)	20.7 (2)	0.1 (14)	36.9 (14)
St. Johns River	0.1 (7)	54.2 (7)	0.2 (6)	93.2 (6)	0.4 (16)	135.6 (16)	0.3 (17)	89.1 (17)	0.3 (46)	100.5 (46)
St. Marys—Nassau River	--------	--------	--------	--------	0.1 (1)	147.1 (1)	--------	--------	0.1 (1)	147.1 (1)
Suwannee River	0.1 (7)	89.4 (7)	0.9 (2)	156.0 (2)	0.3 (12)	113.5 (12)	--------	--------	0.3 (21)	109.5 (21)
Tampa Bay Area	--------	--------	0.1 (14)	59.8 (14)	1.8 (3)	89.4 (3)	0.3 (4)	69.6 (4)	0.4 (21)	65.9 (21)
Withlacoochee River	0.1 (10)	30.2 (10)	--------	--------	--------	--------	0.2 (5)	52.0 (5)	0.1 (15)	37.5 (15)
Average	0.1 (61)	54.9 (61)	0.2 (55)	79.5 (55)	0.4 (65)	90.5 (65)	0.3 (38)	66.6 (38)	0.2 (219)	73.7 (219)

Note: Numbers in parentheses indicate number of samples.

The yearly average beta activity in ground water was 2 to 10 times lower than that in surface water in 1962 and 1963. This beta activity can be attributed to fallout. The alpha activity which is attributed to natural activity of minerals is very nearly the same for ground and surface water. Fallout is, therefore, clearly evident by comparison of gross beta radioactivity in raw surface water and raw well water for both 1962 and 1963. However, no obvious trend directly related to fallout from 1962 weapons testing is indicated by the data obtained by water sampling programs.

The annual average gross beta concentrations in surface water for 1962 are about one half of the averages for 1963 in most basins. The gross beta concentrations in ground water for 1963 were usually not very different from those in 1962.

The average gross beta radioactivity in water supplies is well below the standard (*1*) for gross beta radioactivity in drinking water (1,000 pc/liter), as is average gross alpha radioactivity when compared to its standard for drinking water (3 pc/liter with radium present).

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TABLE 2.—GROSS ALPHA AND BETA RADIOACTIVITY IN UNTREATED WELL WATER IN FLORIDA, 1962–1963

[Concentrations in pc/liter]

Sub-Basin	Quarter 1962								1962 average	
	First		Second		Third		Fourth			
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Apalachicola River					0.1 (1)	7.5 (1)			0.1 (1)	7.5 (1)
Choctawatchee River	1.8 (1)	5.5 (1)			0.7 (5)	17.2 (5)			0.9 (6)	15.3 (6)
Kissimmee River							Bkg. (1)	5.8 (1)	Bkg. (1)	5.8 (1)
Lower Florida Area	0.1 (3)	20.7 (3)					0.2 (8)	34.9 (8)	0.4 (11)	31.0 (11)
Ochlockonee—St. Marks River	0.3 (4)	Bkg. (4)					0.1 (5)	4.0 (5)	0.2 (9)	2.2 (9)
Peace River							Bkg. (1)	61.7 (1)	Bkg. (1)	61.7 (1)
Perdido—Escambia Rivers	1.9 (1)	6.3 (1)			0.6 (3)	8.2 (3)			0.9 (4)	7.7 (4)
Tampa Bay Area			4.2 (1)	19.4 (1)			0.3 (5)	10.8 (5)	1.0 (6)	12.2 (6)
Withlacoochee and Wacassassa Rivers							Bkg. (2)	5.0 (2)	Bkg. (2)	5.0 (2)
Average	0.8 (9)	8.2 (9)	4.2 (1)	19.4 (1)	0.5 (9)	12.3 (9)	0.2 (22)	18.6 (22)	0.5 (41)	14.9 (41)

Sub-Basin	Quarter 1963								1963 average	
	First		Second		Third		Fourth			
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Choctawatchee River	0.1 (1)	10.7 (1)							0.1 (1)	10.7 (1)
Florida East Coastal Area	0.2 (2)	6.3 (2)	0.1 (3)	13.1 (3)	0.4 (1)	10.7 (1)	0.1 (2)	12.4 (2)	0.2 (8)	10.9 (8)
Lower Florida Area	Bkg. (1)	6.4 (1)	0.5 (5)	26.6 (5)	0.3 (2)	14.6 (2)	Bkg. (1)	8.1 (1)	0.3 (9)	1[illegible].6 (9)
Ochlockonee—St. Marks River	Bkg. (5)	12.5 (5)							Bkg. (5)	21.5 (5)
Perdido—Escambia Rivers			0.2 (2)	8.6 (2)			0.3 (3)	10.9 (3)	0.3 (5)	10.0 (5)
St. Johns River	0.2 (1)	7.6 (1)	0.3 (2)	80.2 (2)	0.1 (2)	31.5 (2)	0.2 (2)	7.1 (2)	0.2 (7)	37.6 (7)
Suwannee River					0.6 (1)	11.7 (1)			0.6 (1)	11.7 (1)
Tampa Bay Area			0.3 (1)	11.3 (1)					0.3 (1)	11.3 (1)
Withlacoochee River	0.2 (5)	8.3 (5)					0.3 (1)	13.5 (1)	0.2 (6)	9.2 (6)
Average	0.1 (15)	12.4 (15)	0.3 (13)	29.2 (13)	0.3 (6)	19.1 (6)	0.2 (9)	10.3 (9)	0.2 (43)	18.0 (43)

Note: Number in parentheses indicates number of samples.

TABLE 3.—GROSS ALPHA AND BETA RADIOACTIVITY IN RAW WATER IN FLORIDA IN 1962 AND 1963

[Concentrations in pc/liter]

Location	Quarter								Yearly average	
	First		Second		Third		Fourth			
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
1962										
Alachua County: (19 sampling locations)	2.0 (57)	62.1	0.9 (57)	35.6	1.9 (57)	33.5	1.2 (38)	49.0	1.6 (209)	45.0
City of Gainesville	0.3 (68)	11.6	0.5 (73)	22.4	0.5 (78)	11.6	0.4 (89)	13.3	0.4 (308)	14.5
1963										
Alachua County: (19 sampling locations)	1.7 (57)	67.3	0.8 (19)	79.8	1.0 (57)	43.3	0.6 (57)	22.4	1.1 (190)	47.7
City of Gainesville	0.7 (84)	15.3	0.3 (81)	18.8	0.2 (81)	9.6	0.4 (90)	5.6	0.4 (336)	13.2

Note: Numbers in parentheses indicate number of samples.

REFERENCE

(*1*) Public Health Service: *Public Health Service Drinking Water Standards, Revised 1962.* Publication No. 956, U. S. Government Printing Office, Washington, D.C., 1963. Price: 30 cents.

RADIOACTIVITY IN MINNESOTA SURFACE WATER SUPPLIES, JANUARY—JUNE 1964[1]

Division of Environmental Health
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled, but six surface streams and lakes are now sampled routinely (see figure 1). "Grab" samples of raw and treated water are collected weekly at each station. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory where they are analyzed for gross beta activity. A 250-ml sample of water is evaporated at 75° C. from a two-inch planchet. The solid residue (suspended plus dissolved solids) is fixed by adding lucite in acetone. Afterwards, this sample is counted for beta activity with an internal proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows the monthly average gross beta activity in Minnesota surface water from January–June 1964. The minimum reported level is a convenient low value not normally exceeded by one standard deviation; this is 15 pc/liter at present. In averaging, the value 7 pc/liter is used for samples having less than the minimum detectable value.

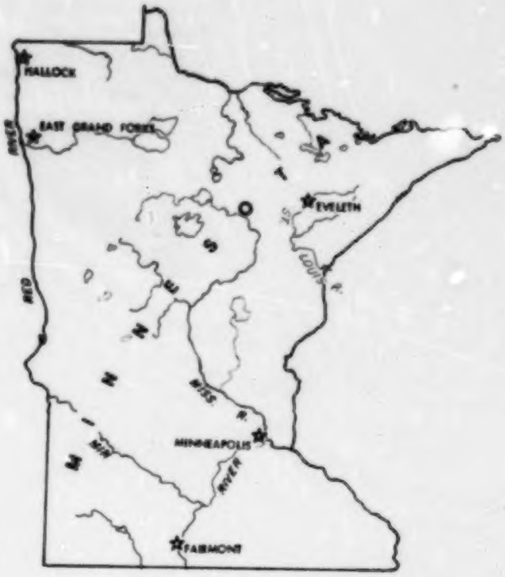

FIGURE 1.—SURFACE WATER SAMPLING LOCATIONS

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variation in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 7 to 78 pc/liter. Treated water in most cases contained less beta activity than the corresponding raw water.

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[1] Data and information from "Survey of Environmental Radioactivity, January–June 1964." State of Minnesota Department of Public Health, University Campus, Minneapolis 14, Minnesota 55440.

TABLE 1.—TOTAL BETA CONCENTRATIONS IN MINNESOTA RAW AND TREATED WATER FROM SURFACE SUPPLIES, JANUARY-JUNE 1964

[Monthly average concentrations in pc/liter]

Town and water source	Type of water	Jan	Feb	Mar	April	May	June
East Grand Forks, Red Lake River	Raw	22	22	26	42	61	64
	Treated	7	7	11	14	30	32
Eveleth, St. Mary's Lake	Raw	23	20	36	16	23	31
	Treated	20	24	20	10	24	18
Fairmount, Budd Lake	Raw	40	28	25	25	20	14
	Treated	13	20	7	7	7	10
Hallock, Two Rivers South Fork	Raw	39	45	32	53	62	78
	Treated	23	10	18	15	18	22
Minneapolis Tap Water	Raw	[a]—	—	—	—	—	—
	Treated	12	7	9	10	16	13
St. Paul, Vadnais Chain of Lakes	Raw	23	12	24	18	23	11
	Treated	18	7	7	7	14	11

[a] Dash indicates no sample.

Previous coverage in *Radiological Health Data*:

Period	Issue
October 1957–August 1959	*April 1960*
August 1959–April 1962	*August 1962*
April 1962–November 1962	*April 1963*
December 1962–June 1963	*November 1963*
July–December 1963	*June 1964*

Section IV—Other Data

MICHIGAN DEPARTMENT OF HEALTH REACTOR ENVIRONMENTAL SURVEILLANCE PROGRAM—A SUMMARY REPORT

G. A. Jacobson, D. E. Van Farowe, J. M. Hennigan, R. C. Bennett

INTRODUCTION

In January 1955 the Atomic Energy Commission began a power reactor demonstration program to promote the commercial use of nuclear power. Since that time two power reactors have been built in Michigan.

The Enrico Fermi power reactor, built by the Power Reactor Development Corporation, is located on the shores of Lake Erie about ten miles northeast of Monroe and 30 miles southwest of Detroit. It is a fast breeder type reactor, fueled with enriched uranium, cooled with liquid sodium, and designed for an initial capacity of 100 megawatts of electrical power. Although construction was begun in 1957, because of several technical difficulties the reactor did not become operational until August 23, 1963.

The Big Point power reactor, built by Consumers Power Company, is located on the shores of Lake Michigan about 5 miles northeast of Charlevoix. It is a pressurized boiling water reactor, fueled with slightly enriched uranium and designed for an initial capacity of 50 megawatts of electrical power. Construction at Big Rock Point began in the spring of 1960, and the reactor became operational on September 27, 1962.

The Michigan Department of Health, in carrying out its responsibilities to protect the health of the people of Michigan, has worked closely with both the Power Reactor Development Corporation and the Consumers Power Company in reviewing safety factors during the construction of the reactors. A basic concern in reactor design is the prevention of the release of radioactive materials to the environment under any but carefully controlled and monitored conditions. Tolerance standards for this release have been carefully established (*1*) (*2*). As a safety measure the reactors are encased in high integrity steel containment enclosures designed to limit any accidental release of radioactivity. However, it is not the purpose of this paper to go into details of the safeguards built into the design of these plants, but instead to discuss elements of the planning, initiating, and carrying out a monitoring program, and to present some typical monitoring data.

Essentially, a monitoring program is a means of substantiating whether or not control mechanisms are operating properly. To do this it is necessary to be able to detect radioactive materials that have been released into the environs in excess of allowable limits referenced previously.

The monitoring program was established by the department with the following objectives:

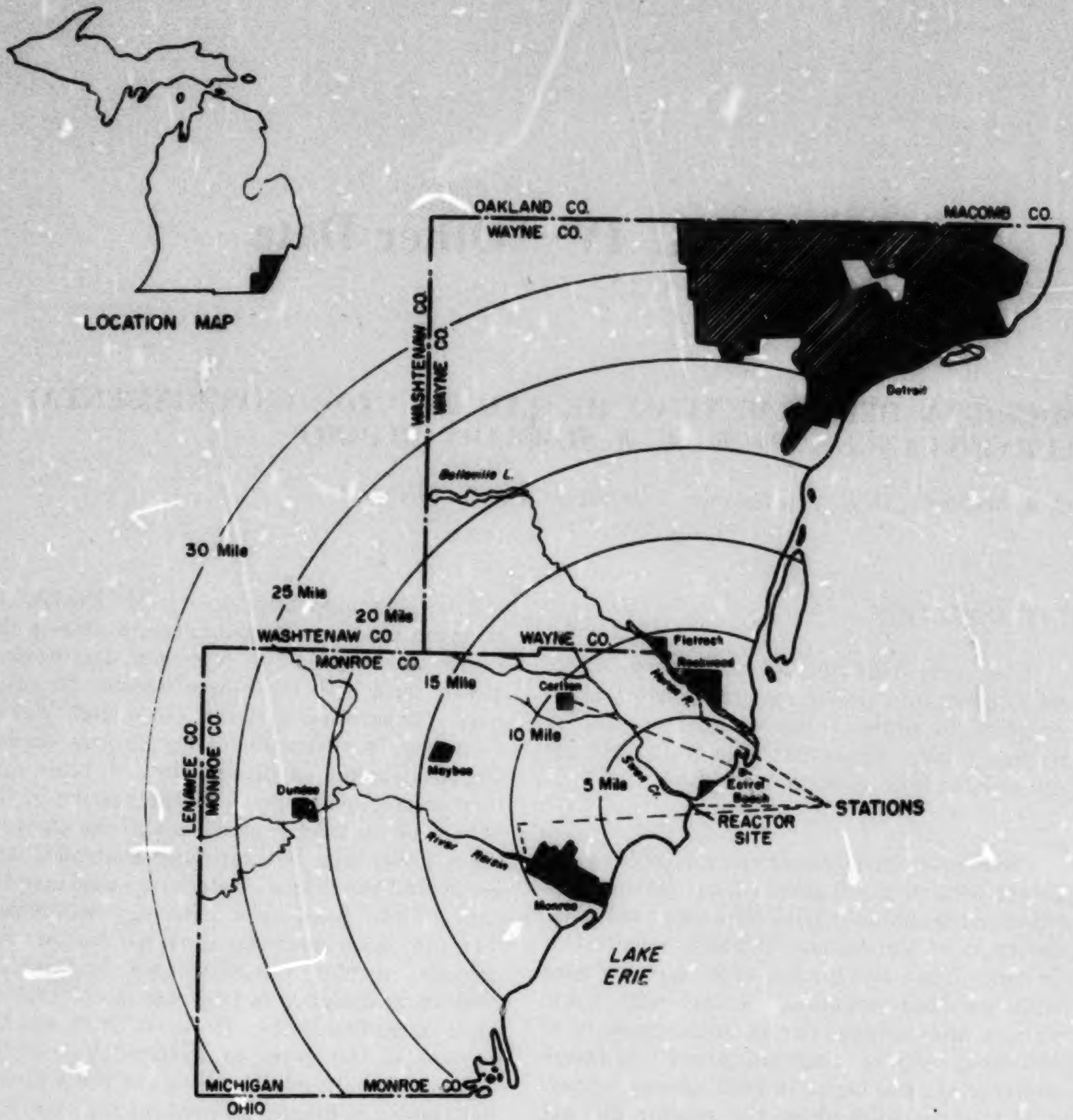
LOCATION MAP
OAKLAND CO.
WAYNE CO.
MACOMB CO.
WASHTENAW CO.
WAYNE CO.
Detroit
Belleville L.
30 Mile
25 Mile
20 Mile
15 Mile
10 Mile
5 Mile
WASHTENAW CO
MONROE CO
WAYNE CO.
Flatrock
Rockwood
Huron R.
Carleton
LENAWEE CO.
MONROE CO.
Maybee
Dundee
Swan Cr.
Estral Beach
STATIONS
REACTOR SITE
River Raisin
Monroe
LAKE ERIE
MICHIGAN
OHIO
MONROE CO.

Figure 1.—ENRICO FERMI ATOMIC POWER PLANT, MONROE COUNTY, MICHIGAN, AIR SAMPLING STATION LOCATIONS

1. Establish pre-operational levels of radioactivity around the plant sites and populated areas from natural background and fallout.
2. Establish standard operating procedures for sampling, laboratory separations, and counting of samples to provide a basis for comparison of sample results with those of Enrico Fermi and Big Rock Point reactors, and other agencies.
3. Establish levels of radioactivity in three areas of the State so that abnormal trends can be detected in one particular area.
4. Protect the health of the workers at the reactor sites and the population at large by taking steps to minimize the hazards should environmental reconcentration of radioactive materials be detected or an accident occur.

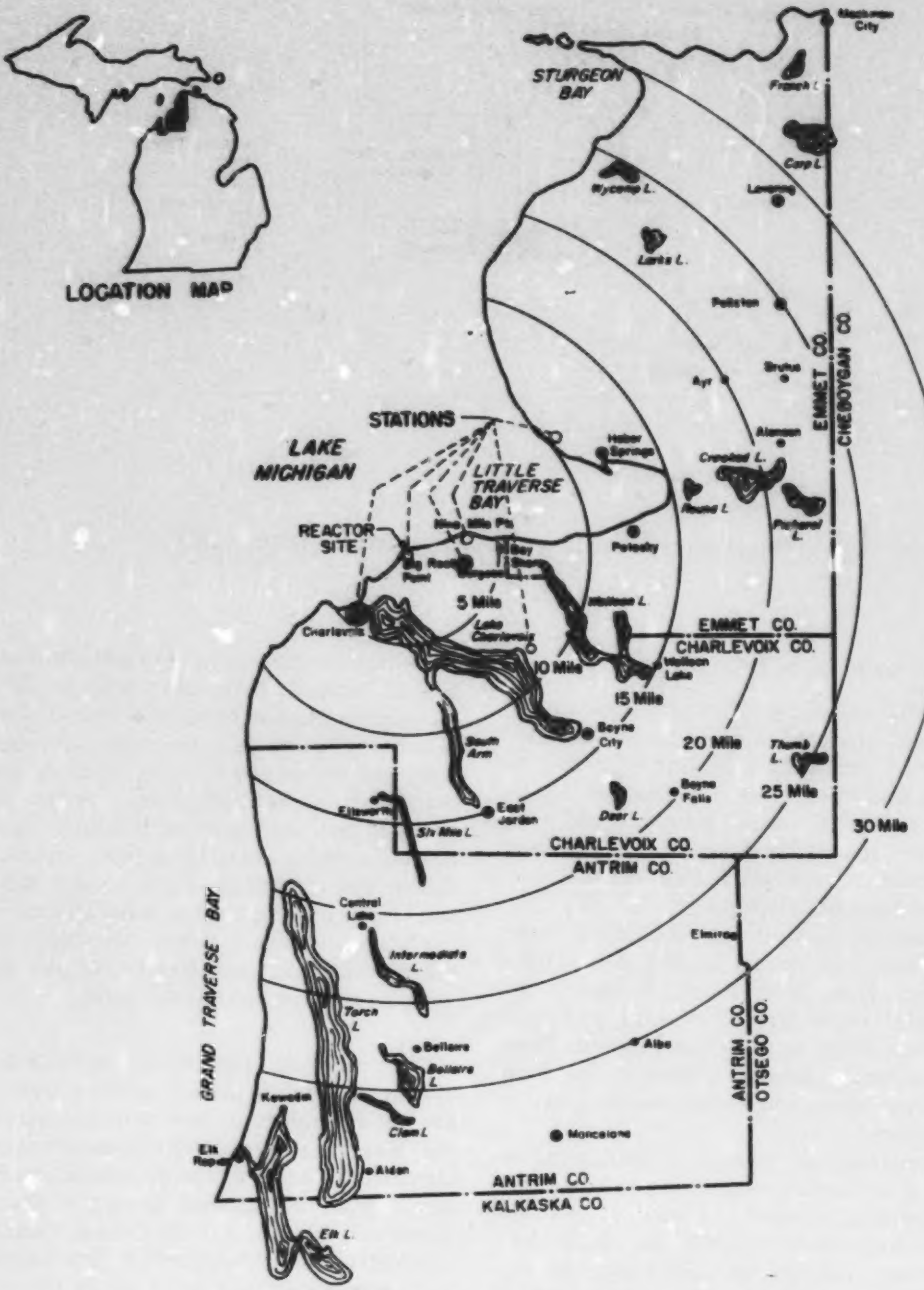
LOCATION MAP
STURGEON BAY
Mackinaw City
French L.
Carp L.
Wycamp L.
Levering
Larks L.
Pellston
Brutus
Ayr
Alanson
EMMET CO.
CHEBOYGAN CO.
STATIONS
LAKE MICHIGAN
LITTLE TRAVERSE BAY
Harbor Springs
Crooked L.
Round L.
Pickerel L.
REACTOR SITE
Nine Mile Pt.
Big Rock Point
Bay Shore
Petoskey
5 Mile
Walloon L.
Charlevoix
Lake Charlevoix
10 Mile
Walloon Lake
15 Mile
EMMET CO.
CHARLEVOIX CO.
Boyne City
South Arm
20 Mile
Thumb L.
25 Mile
Boyne Falls
Deer L.
Ellsworth
East Jordan
Six Mile L.
30 Mile
CHARLEVOIX CO.
ANTRIM CO.
GRAND TRAVERSE BAY
Central Lake
Elmira
Intermediate L.
Torch L.
Bellaire
Bellaire L.
Alba
ANTRIM CO.
OTSEGO CO.
Kewadin
Clam L.
Mancelona
Elk Rapids
Alden
ANTRIM CO.
KALKASKA CO.
Elk L.

FIGURE 2.—BIG ROCK POINT ATOMIC POWER PLANT, CHARLEVOIX COUNTY, MICHIGAN, AIR SAMPLING STATION LOCATIONS

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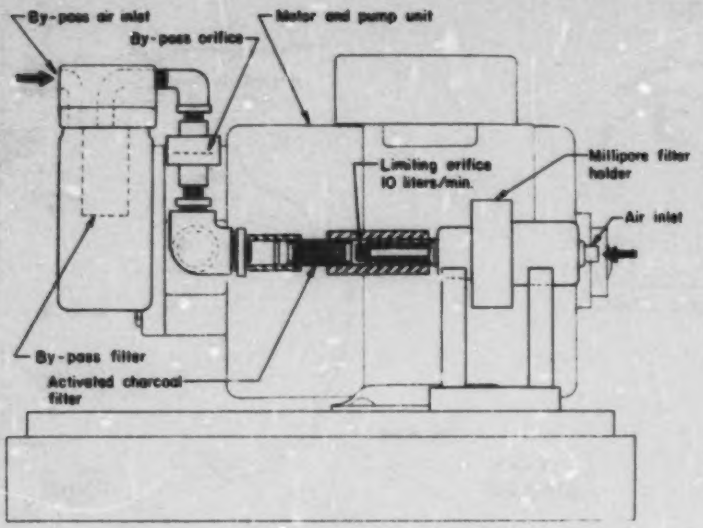

FIGURE 3.—MOTORAIR PUMP; MILLIPORE FILTER AND BY-PASS DETAIL

Materials, Methods, and Results

The initial sampling network at the Enrico Fermi Plant consisted of four stations as noted on figure 1. One station is located at the reactor site and others are at Rockwood, Carleton, and Monroe, all within a ten mile radius of the reactor site. Criteria used in determining these locations were population density, distance, and local meteorology.

The stations around the Big Rock Point Atomic Plant are located at Big Rock Point, Charlevoix, Nine Mile Point, Burgess, two miles northwest of Harbor Springs, and near Young State Park, as shown on figure 2. Here again population density, distance, and local meteorology were considered when locating these stations.

Air sampling was started in September of 1958. Soil evaluation, iodine vapor sampling, mouse sampling, vegetation sampling, and rain collection were added in 1959. Air particulate samples are collected on membrane filters.[1] Air is drawn through the filters with a suction pump[2] at the rate of 9 to 10.5 liters per minute. The sampling time is seven days and the samples are counted three days later to minimize the contribution of radon and thoron daughter activity. For details of the filter holder mechanism and bypass see figure 3. This system has been very dependable, some pumps having operated five years without difficulty. Air particulate samples are counted with the low background anti-coincidence beta counter for gross beta activity. A sample of some typical results is shown in tables 1 and 2. In 1961 a station to collect air and precipitation samples was set up in Lansing as a reference point.

The counting equipment mentioned previously is able to detect activity over background equivalent to less than ten percent of the Maximum Permissible Concentration for uncontrolled areas at the 95 percent confidence level. From the National Bureau of Standards Handbook 69 (*3*), the Maximum Permissible Concentration for unidentified beta emitters is 10^{-11} microcuries per cc of air in the vicinity of an atomic reactor (if there are no α emitters and if Pb^{210}, Ac^{227}, Ra^{228} and Pu^{241} are not present). The detection limit is then 10^{-12} microcuries per cc of air with the sampling system utilized.

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[1] Type AA Millipore filters were used. Millipore Filter Corp., Bedford, Mass.

[2] Moto Air size CAC pumps are used. New Jersey Machine Corp., Hoboken, N.J. .

Activated charcoal cartridges for sampling iodine–131 are collected and replaced concurrently with air particulate samples. A detailed drawing of the filter cartridge is shown in figure 4. Cartridges developed by Sill (4) were assembled by Department personnel. The cartridge is inserted in series with the membrane filter holder as shown in figure 3. The fine screen in the cartridge prevents contamination of the pump with charcoal particles. An air particulate filter is not needed in the cartridge, since air particulates are filtered by the membrane filter. The cartridges are sized so that they fit, inlet side down, in a standard $^{31}/_{32}$-inch diameter by 1½ inches deep scintillation crystal for counting.

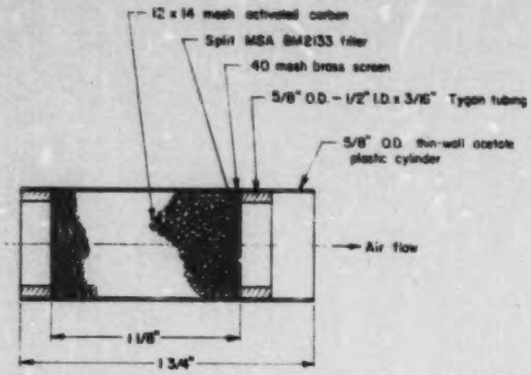
12 x 14 mesh activated carbon
Split MSA BM2133 filter
40 mesh brass screen
5/8" O.D. – 1/2" I.D. x 3/16" Tygon tubing
5/8" O.D. thin-wall acetate plastic cylinder
Air flow
1 1/8"
1 3/4"

FIGURE 4.—ACTIVATED CARBON FILTER CARTRIDGE

Activated charcoal cartridges are analyzed with a well type scintillation counter for total gamma radiation. Further analysis may be made by the gamma spectrometer on those samples showing significant activity.

Rain samples are collected in polyethylene containers by means of polyethylene funnels. Details for this apparatus are shown in figure 5. Samples are collected concurrently with air particulate samples. Each sample is evaporated by simmering to a volume which can be transferred to a planchet for final evaporation. Results are reported in microcuries per milliliter of sample and microcuries per square centimeter per day. Typical results are shown in tables 3 to 6.

Mice are caught around the reactor site sampling stations with common snap traps. Mice were chosen as a possible indicator of environ-

TABLE 1.—ENRICO FERMI REACTOR ENVIRONMENTAL AIR PARTICULATE BETA ACTIVITY THREE DAYS AFTER COLLECTION

[Limit of counting error at the 95% confidence level shown in parentheses]

Date End of Collection	Activity (pc/m³)—3 days after collection			
	Station 1L, Lansing		Station 4, Reactor Site	
9-5-61	0.049	(12%)	0.050	(12%)
9-11-61	0.048	(17%)	0.052	(14%)
9-18-61	10.4	(1%)	10.7	(1%)
9-25-61	17	(2%)	15	(2%)
10-2-61	4.3	(1%)	5.1	(1%)
10-9-61	6.9	(1%)	6.8	(1%)
10-16-61	4.4	(1%)	4.1	(1%)
10-23-61	4.5	(1%)	5.1	(1%)
10-30-61	5.4	(1%)	5.7	(1%)
11-6-61	1.2	(2%)	4.9	(1%)
11-13-61	9.1	(1%)	10.7	(1%)
11-20-61	4.4	(1%)	5.0	(1%)
11-27-61	6.7	(1%)	5.7	(1%)
12-4-61	6.6	(1%)	4.2	(1%)
12-11-61	4.4	(1%)	5.3	(1%)
12-18-61	2.4	(2%)	2.8	(2%)
12-26-61	5.4	(1%)	5.6	(1%)
1-2-62	2.9	(1%)	3.3	(1%)
1-8-62	4.1	(1%)	5.4	(1%)
1-15-62	5.7	(1%)	2.8	(3%)
1-22-62	7.9	(1%)	5.2	(1%)
1-29-62	5.5	(1%)	5.7	(1%)
2-5-62	3.9	(1%)	4.6	(1%)
2-12-62	4.9	(1%)	4.9	(1%)
2-19-62	5.7	(1%)	6.1	(1%)
2-26-62	4.4	(1%)	4.5	(1%)
3-5-62	5.1	(1%)	5.1	(1%)
3-12-62	3.9	(1%)	4.6	(1%)
3-19-62	3.5	(1%)	3.7	(1%)
3-26-62	6.9	(1%)	—	—
4-2-62	5.8	(1%)	5.0	(1%)
4-9-62	5.3	(1%)	5.2	(1%)
4-16-62	4.9	(1%)	4.5	(1%)
4-23-62	4.7	(1%)	5.2	(1%)
4-30-62	7.3	(1%)	6.8	(1%)
5-7-62	4.4	(1%)	4.1	(1%)
5-14-62	5.5	(1%)	4.6	(1%)
5-21-62	3.2	(2%)	5.2	(1%)
5-28-62	4.2	(1%)	4.2	(1%)
6-4-62	1.4	(2%)	2.5	(2%)
6-11-62	5.0	(1%)	4.0	(1%)
6-18-62	5.0	(1%)	6.3	(1%)
6-25-62	3.7	(1%)	3.9	(1%)
7-2-62	4.2	(2%)	4.4	(1%)
7-9-62	2.2	(2%)	3.4	(2%)
7-16-62	5.8	(1%)	4.1	(1%)
7-23-62	2.2	(2%)	2.5	(2%)
7-30-62	2.7	(1%)	2.7	(2%)
8-6-62	1.8	(2%)	1.7	(2%)
8-13-62	1.9	(2%)	—	—
8-20-62	2.0	(2%)	2.0	(2%)
8-27-62	1.7	(2%)	2.0	(2%)
9-4-62	1.7	(2%)	3.9	(1%)
9-10-62	5.0	(1%)	5.4	(2%)
9-17-62	2.7	(2%)	—	—
9-24-62	3.7	(1%)	3.8	(2%)
10-1-62	3.0	(2%)	2.4	(2%)
10-8-62	2.7	(2%)	4.9	(1%)
10-15-62	1.5	(3%)	2.9	(2%)
10-22-62	63	(2%)	7.7	(1%)
10-29-62	3.6	(1%)	3.4	(2%)
11-5-62	2.5	(2%)	2.6	(2%)
11-13-62	5.3	(1%)	8.9	(1%)
11-19-62	5.4	(1%)	10	(1%)
11-26-62	4.5	(1%)	8.1	(1%)
12-3-62	13	(1%)	32	(1%)
12-10-62	8.2	(1%)	4.3	(1%)
12-17-62	4.9	(1%)	4.0	(1%)
12-24-62	3.1	(2%)	5.9	(1%)
12-31-62	8.3	(1%)	—	--
1-7-63	2.6	(2%)	3.2	(2%)
1-14-63	4.2	(2%)	8.8	(1%)
1-21-63	9.3	(1%)	8.5	(2%)
1-28-63	6.3	(1%)	7.8	(1%)

TABLE 2.—BIG ROCK POINT REACTOR ENVIRONMENTAL AIR PARTICULATE BETA ACTIVITY THREE DAYS AFTER COLLECTION

[Limit of counting error at the 95% confidence level in parentheses]

Date end of collection	Activity (pc/m³)—3 days after collection					
	Station 1 Charlevoix	Station 2 Reactor Site	Station 3 Burgess	Station 4 9 Mile Point	Station 5 5 Mile Creek	Station 6 Oyster Bay
9-9-61	0.050 (18%)	0.041 (16%)	0.040 (16%)	— —	0.044 (18%)	0.033 (22%)
9-16-61	3.62 (1%)	2.68 (1%)	0.67 (4%)	3.97 (1%)	1.04 (3%)	0.30 (5%)
9-23-61	43.0 (3%)	41.0 (3%)	46.0 (3%)	33.0 (3%)	15.0 (5%)	40.0 (4%)
9-30-61	4.0 (1%)	4.8 (1%)	4.0 (1%)	4.0 (1%)	3.2 (1%)	3.7 (1%)
10-7-61	8.5 (1%)	6.7 (1%)	6.9 (1%)	5.8 (1%)	— —	6.4 (1%)
10-14-61	4.5 (1%)	4.2 (1%)	4.9 (1%)	4.8 (1%)	5.3 (1%)	4.2 (1%)
10-21-61	5.6 (1%)	4.1 (1%)	6.3 (1%)	4.1 (1%)	5.3 (1%)	3.2 (2%)
10-28-61	4.1 (1%)	4.8 (1%)	5.5 (1%)	5.6 (1%)	4.1 (1%)	4.1 (1%)
11-4-61	6.5 (1%)	5.3 (1%)	6.6 (1%)	5.7 (1%)	7.2 (1%)	5.5 (1%)
11-11-61	7.8 (1%)	4.6 (1%)	9.3 (1%)	5.7 (1%)	6.1 (1%)	5.7 (1%)
11-18-61	13.1 (1%)	12.2 (1%)	13.6 (1%)	4.2 (1%)	11.6 (1%)	4.8 (1%)
11-25-61	6.1 (1%)	4.9 (1%)	5.0 (1%)	6.2 (1%)	5.2 (1%)	5.6 (1%)
12-2-61	4.7 (1%)	4.1 (1%)	4.4 (1%)	4.1 (1%)	5.7 (1%)	4.8 (1%)
12-9-61	5.4 (1%)	5.4 (1%)	6.6 (1%)	6.3 (1%)	5.7 (1%)	3.2 (1%)
12-16-61	2.7 (2%)	2.6 (2%)	2.7 (2%)	2.2 (2%)	3.0 (2%)	2.7 (2%)
12-23-61	4.3 (1%)	4.9 (1%)	4.2 (1%)	1.8 (2%)	4.5 (1%)	4.3 (1%)
12-30-61	4.4 (1%)	4.7 (1%)	4.2 (1%)	5.1 (1%)	4.4 (1%)	3.5 (1%)
1-6-62	7.2 (1%)	8.0 (1%)	6.7 (1%)	7.0 (1%)	6.7 (1%)	5.9 (1%)
1-13-62	7.6 (1%)	7.4 (1%)	8.6 (1%)	7.7 (1%)	9.0 (1%)	7.8 (1%)
1-20-62	7.0 (1%)	— —	7.2 (1%)	7.1 (1%)	7.7 (1%)	7.0 (1%)
1-27-62	6.9 (1%)	6.9 (1%)	6.6 (1%)	7.4 (1%)	7.9 (1%)	6.6 (1%)
2-3-62	4.0 (1%)	4.8 (1%)	4.3 (1%)	5.1 (1%)	5.2 (1%)	5.0 (1%)
2-10-62	4.1 (1%)	4.8 (1%)	4.7 (1%)	4.1 (1%)	4.3 (1%)	4.9 (1%)
2-17-62	8.1 (1%)	9.1 (1%)	7.8 (1%)	8.4 (1%)	7.9 (1%)	8.7 (1%)
2-24-62	5.4 (1%)	5.3 (1%)	5.4 (1%)	5.1 (1%)	5.1 (1%)	5.2 (1%)
3-3-62	5.3 (1%)	5.7 (1%)	5.6 (1%)	6.2 (1%)	5.6 (1%)	5.7 (1%)
3-10-62	5.6 (1%)	5.4 (1%)	5.5 (1%)	5.8 (1%)	5.7 (1%)	5.6 (1%)
3-17-62	4.4 (1%)	4.4 (1%)	4.6 (1%)	4.4 (1%)	4.2 (1%)	4.2 (1%)
3-24-62	4.2 (1%)	4.4 (1%)	4.5 (1%)	4.4 (1%)	4.5 (1%)	4.8 (1%)
3-31-62	6.7 (1%)	6.9 (1%)	7.1 (1%)	6.0 (1%)	6.8 (1%)	6.8 (1%)
4-7-62	6.0 (1%)	6.3 (1%)	6.6 (1%)	7.2 (1%)	6.0 (1%)	6.1 (1%)
4-14-62	5.3 (1%)	4.8 (1%)	5.1 (1%)	4.8 (1%)	4.9 (1%)	5.2 (1%)
4-21-62	4.0 (1%)	4.0 (1%)	4.3 (1%)	3.9 (1%)	4.1 (1%)	4.2 (1%)
4-28-62	5.7 (1%)	5.5 (1%)	5.5 (1%)	5.1 (1%)	4.5 (1%)	5.7 (1%)
5-5-62	2.8 (3%)	3.0 (2%)	3.0 (2%)	2.6 (2%)	2.8 (2%)	3.1 (2%)
5-12-62	4.6 (1%)	5.2 (1%)	5.2 (1%)	5.4 (1%)	4.9 (1%)	4.6 (1%)
5-19-62	7.6 (1%)	6.0 (1%)	6.7 (1%)	5.6 (1%)	5.7 (1%)	6.4 (1%)
5-26-62	14 (1%)	5.1 (1%)	5.2 (1%)	4.8 (1%)	5.4 (1%)	4.6 (1%)
6-2-62	2.9 (2%)	2.7 (2%)	3.0 (2%)	2.9 (2%)	3.0 (2%)	2.7 (2%)
6-9-62	4.9 (1%)	5.4 (1%)	5.6 (1%)	5.4 (1%)	5.1 (1%)	5.2 (1%)
6-16-62	6.6 (1%)	6.0 (1%)	6.1 (1%)	5.5 (1%)	7.0 (1%)	6.0 (1%)
6-23-62	4.1 (1%)	3.7 (1%)	10 (1%)	3.9 (1%)	4.2 (1%)	4.2 (1%)
6-30-62	4.2 (2%)	4.4 (1%)	4.9 (1%)	4.7 (1%)	4.3 (1%)	4.9 (1%)
7-7-62	5.5 (1%)	5.2 (1%)	5.2 (1%)	5.4 (1%)	5.9 (1%)	5.1 (1%)
7-14-62	3.9 (1%)	4.1 (1%)	4.2 (1%)	4.1 (1%)	4.0 (1%)	3.9 (1%)
7-21-62	1.9 (2%)	2.1 (2%)	2.1 (2%)	1.5 (2%)	2.0 (2%)	2.1 (2%)
7-28-62	5.2 (1%)	2.5 (2%)	2.7 (2%)	2.6 (2%)	2.6 (2%)	2.5 (2%)
8-4-62	2.8 (2%)	2.7 (2%)	2.7 (2%)	2.8 (2%)	3.1 (2%)	2.6 (2%)
8-11-62	2.1 (2%)	1.9 (2%)	1.9 (2%)	— —	2.0 (2%)	1.7 (2%)
8-18-62	1.9 (2%)	2.1 (2%)	2.0 (2%)	1.9 (2%)	1.9 (2%)	2.0 (2%)
8-25-62	2.1 (2%)	2.2 (2%)	1.8 (2%)	1.8 (2%)	1.9 (2%)	1.8 (2%)
9-1-62	3.0 (2%)	3.3 (2%)	3.0 (2%)	2.1 (2%)	1.7 (2%)	2.8 (2%)
9-8-62	5.7 (1%)	9.5 (5%)	5.3 (6%)	2.2 (2%)	6.1 (1%)	5.8 (1%)
9-15-62	2.7 (2%)	2.7 (2%)	2.4 (2%)	— —	3.5 (1%)	3.5 (1%)
9-24-62	6.6 (1%)	5.3 (1%)	4.7 (1%)	6.1 (1%)	4.5 (1%)	3.9 (1%)
9-29-62	3.0 (2%)	3.4 (1%)	2.6 (2%)	2.3 (2%)	2.1 (2%)	2.2 (2%)
10-6-62	5.2 (1%)	5.5 (1%)	5.0 (1%)	5.5 (1%)	5.6 (1%)	5.2 (1%)
10-13-62	2.1 (2%)	2.5 (2%)	2.6 (2%)	2.6 (2%)	2.2 (2%)	2.1 (2%)
10-20-62	3.6 (2%)	3.8 (1%)	4.3 (1%)	3.3 (2%)	4.2 (1%)	3.9 (1%)
10-27-62	4.1 (1%)	4.2 (1%)	3.7 (1%)	4.3 (1%)	4.2 (1%)	4.7 (1%)
11-5-62	3.3 (2%)	3.3 (2%)	7.1 (1%)	2.4 (2%)	4.2 (1%)	3.6 (1%)
11-10-62	4.5 (1%)	4.7 (1%)	3.2 (1%)	4.8 (1%)	3.7 (1%)	2.6 (1%)
11-17-62	8.2 (1%)	10 (1%)	7.8 (1%)	9.0 (1%)	8.0 (1%)	5.7 (1%)
11-24-62	4.9 (1%)	7.1 (1%)	5.9 (1%)	4.5 (1%)	4.5 (1%)	3.7 (1%)
12-1-62	22 (3%)	26 (3%)	21 (3%)	14 (1%)	19 (1%)	23 (3%)
12-8-62	9.4 (1%)	7.7 (1%)	7.8 (1%)	6.0 (1%)	5.4 (1%)	2.7 (2%)
12-15-62	4.0 (1%)	4.0 (1%)	4.2 (1%)	5.0 (1%)	4.1 (1%)	4.4 (1%)
12-22-62	6.1 (1%)	7.0 (1%)	5.2 (1%)	5.1 (1%)	5.7 (1%)	5.6 (1%)
12-29-62	6.9 (1%)	8.7 (1%)	7.1 (1%)	9.6 (1%)	6.9 (1%)	8.0 (1%)

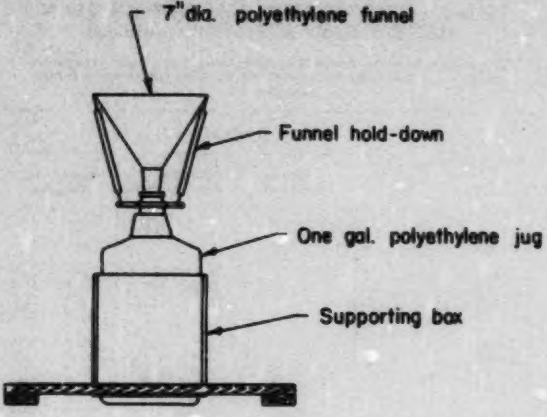

FIGURE 5.—RAIN SAMPLER

mental reconcentration and are the only mammals readily available at both reactor sites. They are weighed, the skin is removed, and after the thyroids have been removed the carcasses are digested in concentrated nitric acid. Thyroids are analyzed by the same counting system used for the charcoal filters described previously. A radioactive barium-strontium determination is performed on the carcass. The results are reported in microcuries of barium-stontium beta activity per gram of mouse, as noted in table 7.

Vegetation samples consisting of plants such as corn, soy beans, and grass are collected in the vicinity of each station on a weekly basis during the growing season. Gross beta activity is determined and reported as shown in tables 8 and 9. Barium-strontium and calcium determinations are also made.

Soil samples have been collected at monthly intervals from the vicinity of each station. Gross beta activity is determined for the acid-soluble portion as microcuries per gram of dry soil as shown in tables 10 and 11.

During the past year a 400-channel gamma spectrometer has been added to the laboratory equipment. Milk is now being collected on a weekly basis from dairy plants located in Charlevoix and Wyandotte, Michigan as well as dairies in five other localities in the state. Milk is checked for iodine-131, cesium-137, potassium-40, and barium-lanthanum-140 activity. An analysis for strontium-90 is also performed on selected samples.

TABLE 3.—ENRICO FERMI REACTOR ENVIRONMENTAL RAIN ACTIVITY

[Gross beta activity expressed in microcuries per milliliter. Limit of counting error at the 95% confidence level in parentheses]

Final Collection Date	Activity—pc/ml. (x 10⁻⁶)			
	Station 1L, Lansing		Station 4, Reactor Site	
8-7-61	1.1*	(13%)	0.90*	(17%)
8-14-61	Trace*		0.63*	(26%)
8-21-61	1.1*	(37%)	0.85*	(32%)
8-28-61	1.0*	(10%)	1.3*	(17%)
9-5-61	0.42*	(31%)	Trace*	
9-11-61	1.3*	(51%)	Trace*	
9-18-61	0.28*	(39%)	2.6*	(28%)
9-25-61	28.*	(3%)	6.9*	(5%)
10-2-61	50.*	(1%)	21.*	(6%)
10-9-61	—	—	—	—
10-16-61	41.*	(4%)	55.*	(6%)
10-23-61	—	—	37.*	(9%)
10-30-61	85.*	(1%)	250.*	(1%)
11-6-61	84.*	(3%)	274.*	(3%)
11-13-61	—	—	222.*	(4%)
11-20-61	59.*	(2%)	35.*	(2%)
11-27-61	100.*	(2%)	62.*	(3%)
12-4-61	—	—	200.*	(3%)
12-11-61	120.*	(2%)	89.*	(3%)
12-18-61	150.*	(2%)	110.*	(3%)
Rain Sampling discontinued during winter.				
3-12-62	—	—	50.*	(3%)
3-19-62	—	—	79.*	(3%)
3-26-62	51.*	(3%)	94.*	(3%)
4-2-62	180.*	(3%)	170.*	(8%)
4-9-62	15.*	(5%)	52.*	(4%)
4-16-62	30.*	(4%)	85.*	(5%)
4-23-62	240.*	(3%)	62.*	(4%)
4-30-62	190.*	(3%)	—	—
5-7-62	65.*	(1%)	71.*	(2%)
5-14-62	110.*	(5%)	—	—
5-21-62	—	—	150.*	(3%)
5-28-62	—	—	87.*	(4%)
6-4-62	240.*	(2%)	180.*	(1%)
6-11-62	40.*	[illegible]	62.*	(3%)
6-18-62	32.*	(2%)	81.*	(3%)
6-25-62	88.*	(2%)	130.*	(2%)
7-2-62	—	—	—	—
7-9-62	8.5*	(4%)	30.*	(2%)
7-16-62	—	—	78.*	(2%)
7-23-62	50.*	(3%)	57.*	(2%)
7-30-62	64.*	(3%)	—	—
8-6-62	18.*	(3%)	—	—
8-13-62	49.*	(4%)	—	—
8-20-62	56.*	(4%)	35.*	(3%)
8-27-62	59.*	(3%)	33.*	(3%)
9-4-62	—	—	26.*	(4%)
9-10-62	30.*	(3%)	20.*	(3%)
9-17-62	42.*	(2%)	29.*	(2%)
9-24-62	150.*	(2%)	160.*	(2%)
10-1-62	—	—	48.*	(4%)
10-8-62	89.*	(2%)	60.*	(2%)
10-15-62	140.*	(4%)	400.*	(4%)
10-22-62	85.*	(2%)	78.*	(2%)
10-29-62	110.*	(2%)	—	—
11-5-62	130.*	(3%)	170.*	(2%)
11-13-62	58.*	(6%)	42.*	(2%)
11-19-62	190.*	(2%)	—	—
11-26-62	—	—	—	—
12-3-62	—	—	—	—
12-10-62	—	—	—	—
Discontinued rain sampling for winter.				

* Gross Beta Activity—No Barium-Strontium Separation
— No Sample Collected

The water pollution program is under the jurisdiction of the Michigan Water Resources Commission and a program of sampling surface water and biota around the reactor sites has been set up by that Commission. Sample results are readily available to this department as part of the general surveillance program.

A program of monitoring external gamma radiation at each station by the use of film badges has been initiated during the past year.

TABLE 4.—ENRICO FERMI REACTOR ENVIRONMENTAL RAIN ACTIVITY

[Gross beta activity expressed in microcuries per square centimeter per day. Limit of counting error at the 95% confidence level in parentheses]

Final Collection Date	Activity—μc/cm²/day (x 10^{-8})	
	Station 1L, Lansing	Station 4, Reactor Site
8-21-61	0.11* (37%)	0.14* (32%)
8-28-61	0.64* (10%)	0.35* (17%)
9-5-61	0.15* (31%)	Trace*
9-11-61	0.07* (51%)	Trace*
9-18-61	0.10* (39%)	0.16* (28%)
9-25-61	9.7* (3%)	3.2* (5%)
10-2-61	40.* (1%)	2.1* (6%)
10-9-61	— —	— —
10-16-61	5.2* (4%)	2.2* (6%)
10-23-61	— —	1.1* (9%)
10-30-61	43.* (1%)	44.* (1%)
11-6-61	9.7* (3%)	10.* (3%)
11-13-61	— —	5.4* (4%)
11-20-61	30.* (2%)	19.* (2%)
11-27-61	19.* (2%)	9.7* (3%)
12-4-61	— —	7.5* (3%)
12-11-61	32.* (2%)	11.* (3%)
12-18-61**	30.* (2%)	11.* (3%)
3-12-62	— —	6.7* (3%)
3-19-62	— —	8.3* (3%)
3-26-62	9.6* (3%)	6.7* (3%)
4-2-62	4.2* (3%)	1.4* (8%)
4-9-62	1.7* (5%)	6.0* (4%)
4-16-62	4.6* (4%)	3.2* (5%)
4-23-62	9.2* (3%)	4.3* (4%)
4-30-62	8.9* (3%)	— —
5-7-62	49.* (1%)	20.* (2%)
5-14-62	3.1* (5%)	— —
5-21-62	— —	11.* (3%)
5-28-62	— —	5.3* (4%)
6-4-62	14.* (2%)	40.* (1%)
6-11-62	20.* (2%)	6.2* (3%)
6-18-62	14.* (2%)	7.6* (3%)
6-25-62	13.* (2%)	25.* (2%)
7-2-62	— —	— —
7-9-62	4.5* (4%)	19.* (2%)
7-16-62	— —	21.* (2%)
7-23-62	11.* (3%)	29.* (2%)
7-30-62	6.2* (3%)	— —
8-6-62	3.2* (3%)	— —
8-13-62	5.4* (4%)	— —
8-20-62	5.4* (4%)	6.3* (3%)
8-27-62	9.1* (3%)	12.* (3%)
9-4-62	— —	4.1* (4%)
9-10-62	7.9* (3%)	6.2* (3%)
9-17-62	14.* (2%)	16.* (2%)
9-24-62	16.* (2%)	13.* (2%)
10-1-62	— —	5.6* (4%)
10-8-62	23.* (2%)	23.* (2%)
10-15-62	5.1* (4%)	5.6* (4%)
10-22-62	28.* (2%)	19.* (2%)
10-29-62	12.* (2%)	— —
11-5-62	11.* (3%)	27.* (2%)
11-13-62	2.3* (6%)	14.* (2%)
11-19-62	23.* (2%)	— —
11-26-62	— —	— —
12-3-62	— —	— —
12-10-62**	— —	— —

Table 4.—ENRICO FERMI REACTOR ENVIRONMENTAL RAIN ACTIVITY—continued

[Gross beta activity expressed in microcuries per square centimeter per day. Limit of counting error at the 95% confidence level in parentheses]

Final Collection Date	Activity μc/cm²/day (x 10^{-8})		
	Station 1-Carleton	Station 4, Reactor Site	Station 1L, Lansing
4-22-63	—	9.8* (3%)	—
4-29-63	—	—	—
5-6-63	—	2.0* (6%)	—
5-13-63	—	0.90* (9%)	82.* (1%)
5-20-63	—	16.* (2%)	22.* (2%)
5-27-63	—	—	15.* (2%)
6-3-63	—	19.* (2%)	25.* (2%)
6-10-63	—	37.* (1%)	200.* (1%)
6-17-63	—	3.0* (5%)	12.* (2%)
6-24-63	—	—	9.0* (3%)
7-1-63	—	—	26.* (2%)
7-9-63	—	—	3.0* (5%)
7-15-63	0.55* (12%)	1.1* (8%)	32.* (1%)
7-22-63	2.2* (6%)	1.7* (7%)	40.* (1%)
7-29-63	2.4* (5%)	4.2* (4%)	— —
8-5-63	3.4* (5%)	3.5* (5%)	54.* (1%)
8-12-63	1.1* (8%)	— —	32.* (1%)

* Gross Beta Activity—No Barium-Strontium Separation.
—No Sample Collected.
** Rain sampling discontinued for winter after this date.
Trace—Net cpm equal to or less than background.

Discussion

From the data obtained it is evident that the air sample results are quite consistent at Monroe, Lansing, and Charlevoix. Thus it is assumed that the data clearly indicate fluctuations due to fallout and natural activity. Should there be a rise in one particular part of the state, it would be quite easily detected. The same is true for individual stations around the reactor site. No significant activity in mice thyroids has been demonstrated to date. (Thus it would appear that milk is a more suitable indicator for iodine in the environment.)

It should be pointed out that there is no such thing as an absolute monitoring system. Unless sampling stations were prohibitively close together, a radioactive plume could pass between two stations with neither station showing activity. Under looping conditions a radioactive cloud could skip over a station. Under lofting conditions a radioactive cloud could remain above the station, yet drop down and touch earth directly behind it. Nevertheless, the monitoring of the Michigan Department of Health, which has been in operation about five years, has satisfied the objectives. Future needs will dictate any changes that may be necessary after reactors have been in operation for some time.

TABLE 5.—BIG ROCK POINT REACTOR ENVIRONMENTAL RAIN ACTIVITY

[Gross beta activity expressed as microcuries per milliter limit of counting error at the 95% confidence level in parentheses]

Final collection date	Activity—μc/ml (x 10⁻⁸)					
	Station 1 Charlevoix	Station 2 Reactor Site	Station 3 Burgess	Station 4 9 Mile Point	Station 5 5 Mile Creek	Station 6 Oyster Bay
8-12-61	0.40 (39%)	1.6 ([illegible])	0.57 (40%)	1.[illegible] (26%)	2.3 (33%)	0.77 (33%)
8-19-61	Trace	1.1	1.1	Trace	7.0	Trace
8-26-61	—	—	—	—	—	—
9-2-61	Trace	0.73 (24%)	0.34 (34%)	0.50 (30%)	.22 (40%)	Trace
9-9-61	—	—	—	—	—	—
9-16-61	0.44 (11%)	.66 (9%)	.41 (11%)	1.1 (7%)	.63 (8%)	0.70 (8%)
9-23-61	7.2 (3%)	8.6 (5%)	11.3 (4%)	14.6 (4%)	22.6 (3%)	15.9 (3%)
9-30-61	5.6 (6%)	19 (4%)	11 (4%)	18 (3%)	10 (5%)	12 (4%)
10-7-61	9.3 (5%)	19 (4%)	12 (5%)	18 (3%)	24 (3%)	10 (8%)
10-14-61	49 (4%)	42 (4%)	25 (5%)	75 (3%)	72 (3%)	52 (3%)
10-21-61	56 (3%)	88 (4%)	41 (3%)	62 (3%)	78 (2%)	115 (2%)
10-28-61	22 (4%)	68 (2%)	24 (4%)	52 (3%)	54 (2%)	26 (3%)
11-4-61	20 (3%)	36 (2%)	24 (2%)	35 (2%)	38 (2%)	30 (2%)
11-11-61	35 (4%)	44 (5%)	27 (4%)	50 (4%)	60 (4%)	29 (4%)
11-18-61	270 (1%)	140 (1%)	93 (1%)	150 (1%)	150 (1%)	28 (3%)
11-25-61	38 (4%)	150 (2%)	100 (2%)	70 (3%)	100 (2%)	85 (3%)
	Discontinued rain sampling for winter.					
4-28-62	81.0 (2%)	34.0 (3%)	1.0 (19%)	54.5 (2%)	64.0 (2%)	73.6 (2%)
5-5-62	16.0 (3%)	8.1 (4%)	33.0 (2%)	22.0 (2%)	41.0 (2%)	28.0 (2%)
5-12-62	90.0 (3%)	92.0 (4%)	140.0 (4%)	87.0 (3%)	72.0 (4%)	110.0 (4%)
5-19-62	40.0 (3%)	30.0 (4%)	58.0 (3%)	43.0 (3%)	49.0 (5%)	62.0 (2%)
5-26-62	100.0 (3%)	14.0 (7%)	82.0 (4%)	38.0 (4%)	60.0 (4%)	17.0 (5%)
6-2-62	98.0 (4%)	58.0 (5%)	110.0 (2%)	21.0 (5%)	100.0 (3%)	41.0 (3%)
6-9-62	—	—	—	—	—	—
6-16-62	4.1 (9%)	30.0 (3%)	12.0 (4%)	33.0 (2%)	10.0 (5%)	44.0 (2%)
6-23-62	42.0 (3%)	42.0 (3%)	31.0 (3%)	100.0 (2%)	44.0 (3%)	23.0 (3%)
6-30-62	38.0 (3%)	130.0 (2%)	52.0 (3%)	68.0 (4%)	320.0 (1%)	88.0 (2%)

TABLE 6.—BIG ROCK POINT REACTOR ENVIRONMENTAL RAIN ACTIVITY

[Gross beta activity expressed as microcuries per square centimeter per day limit of counting error at the 95% confidence level in parentheses]

Final collection date	Activity—μc/cm²/day (x 10⁻⁸)					
	Station 1 Charlevoix	Station 2 Reactor Site	Station 3 Burgess	Station 4 9 Mile Point	Station 5 5 Mile Creek	Station 6 Oyster Bay
8-12-61	0.10 (39%)	0.16 (29%)	0.10 (40%)	0.18 (28%)	0.13 (33%)	0.13 (33%)
8-19-61	Trace	0.10 (39%)	0.11 (37%)	Trace	0.40 (15%)	Trace
8-26-61	— —	— —	— —	— —	— —	— —
9-2-61	Trace	0.20 (24%)	0.13 (34%)	0.15 (30%)	0.10 (40%)	Trace
9-9-61	— —	— —	— —	— —	— —	— —
9-16-61	0.61 (11%)	0.92 (9%)	0.65 (11%)	1.8 (7%)	1.2 (8%)	1.1 (8%)
9-23-61	3.0 (5%)	3.0 (5%)	5.3 (4%)	5.8 (4%)	11.0 (3%)	8.0 (3%)
9-30-61	2.0 (6%)	5.0 (4%)	4.8 (4%)	6.4 (3%)	3.1 (5%)	4.5 (4%)
10-7-61	3.6 (5%)	5.0 (4%)	3.7 (5%)	3.6 (5%)	9.4 (3%)	1.4 (8%)
10-14-61	5.6 (4%)	5.6 (4%)	3.0 (5%)	7.8 (3%)	11 (3%)	10 (3%)
10-21-61	3.4 (5%)	20 (4%)	8.4 (3%)	9.3 (3%)	14 (2%)	22 (2%)
10-28-61	5.4 (4%)	14 (2%)	6.0 (4%)	12 (3%)	13 (2%)	7.6 (3%)
11-4-61	8.9 (3%)	15 (2%)	13 (2%)	15 (2%)	18 (2%)	19 (2%)
11-11-61	4.0 (4%)	3.5 (5%)	4.4 (4%)	5.2 (4%)	5.9 (4%)	5.7 (4%)
11-18-61	54 (1%)	45 (1%)	38 (1%)	42 (1%)	48 (1%)	8.7 (3%)
11-25-61	4.2 (4%)	17 (2%)	13 (2%)	8.6 (3%)	16 (2%)	13 (2%)
	Discontinued rain sampling for winter.					
4-28-62	21 (2%)	10 (3%)	.28 (19%)	16 (2%)	18 (2%)	27 (2%)
5-5-62	8.2 (3%)	3.9 (4%)	17 (2%)	14 (2%)	16 (2%)	17 (2%)
5-12-62	11 (3%)	4.8 (4%)	5.9 (4%)	3.7 (5%)	5.5 (4%)	6.0 (4%)
5-19-62	9.0 (3%)	5.6 (4%)	11 (3%)	7.4 (3%)	10 (3%)	14 (2%)
5-26-62	9.3 (3%)	1.7 (7%)	9.8 (3%)	4.0 (4%)	5.8 (4%)	2.9 (5%)
6-2-62	5.7 (4%)	3.7 (5%)	12 (2%)	3.1 (5%)	6.7 (3%)	3.8 (5%)
6-9-62	— —	— —	— —	— —	— —	— —
6-16-62	1.1 (9%)	11 (3%)	3.9 (4%)	14 (2%)	3.0 (5%)	13 (2%)
6-23-62	8.5 (3%)	7.9 (3%)	6.8 (3%)	20 (2%)	8.8 (3%)	7.0 (3%)
6-30-62	8.6 (3%)	19 (2%)	7.3 (3%)	5.9 (3%)	40 (1%)	13 (2%)
7-7-62	— —	— —	— —	— —	— —	— —
7-14-62	— —	— —	— —	— —	— —	— —
7-21-62	21 (2%)	42 (1%)	17 (2%)	12 (3%)	20 (2%)	13 (2%)
7-28-62	5.7 (4%)	1.9 (6%)	[illegible] (4%)	5.8 (4%)	5.4 (4%)	3.4 (5%)
8-4-62	2.8 (5%)	3.8 (5%)	2.3 (6%)	2.8 (5%)	3.2 (5%)	3.0 (5%)
8-11-62	3.3 (5%)	2.5 (6%)	3.6 (5%)	2.3 (6%)	3.1 (5%)	2.9 (5%)
8-18-62	4.1 (4%)	5.7 (4%)	5.5 (4%)	5.2 (4%)	5.6 (4%)	4.1 (4%)
8-25-62	4.8 (4%)	5.9 (4%)	5.3 (4%)	5.4 (4%)	5.3 (4%)	7.5 (3%)
9-1-62	6.7 (3%)	8.7 (3%)	18 (2%)	6.4 (3%)	10 (3%)	4.8 (4%)
9-8-62	4.3 (4%)	13 (2%)	5.2 (4%)	4.4 (4%)	5.3 (4%)	5.2 (4%)
9-15-62	3.8 (5%)	8.0 (3%)	6.8 (3%)	5.5 (4%)	5.2 (4%)	8.1 (3%)
9-22-62	5.9 (4%)	11 (3%)	7.9 (3%)	8.0 (3%)	12 (2%)	15 (2%)
9-29-62	2.2 (6%)	3.3 (5%)	4.3 (4%)	6.4 (3%)	4.3 (4%)	8.4 (3%)
10-6-62	4.6 (4%)	5.4 (4%)	— —	2.6 (5%)	2.6 (5%)	7.5 (3%)
10-13-62	— —	— —	3.3 (5%)	3.4 (5%)	— —	6.0 (4%)
10-20-62	— —	— —	— —	— —	— —	— —
10-27-62	20 (2%)	23 (2%)	22 (2%)	21 (2%)	23 (2%)	29 (2%)
11-3-62	7.9 (3%)	7.3	(3%)	6.7 (2%)	9.6 (3%)	8.0 (3%)
11-10-62	4.8 (4%)	12 (3%)	78 (1%)	9.0 (3%)	9.4 (3%)	9.2 (3%)
11-17-62	— —	— —	— —	— —	— —	— —
11-24-62	18 (2%)	42 (1%)	5.6 (4%)	23 (2%)	13 (2%)	16 (2%)

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TABLE 7.—BIG ROCK POINT REACTOR ENVIRONMENTAL BIOLOGICAL SAMPLES

[Barium-strontium beta activity in microcuries per gram of mouse. Limit of counting error at the 95% confidence level in parentheses]

Final collection date	Activity—μc/gm (x 10⁻⁷)					
	Station 1 Charlevoix	Station 2 Reactor Site	Station 3 Burgess	Station 4 9 Mile Point	Station 5 5 Mile Creek	Station 6 Oyster Bay
6-24-61	— —	1.1 (30%)	— —	— —	— —	— —
7-1-61	— —	.67 (35%)	— —	Trace	— —	— —
7-8-61	— —	1.0 (17%)	— —	Trace	— —	— —
7-29-61	— —	1.5 (15%)	— —	.38 (35%)	— —	— —
8-5-61	— —	.86 (25%)	— —	1.2 (22%)	— —	— —
8-12-61	— —	—	— —	Trace	— —	— —
8-19-61	— —	1.8 (22%)	Trace	—	1.2 (35%)	— —
8-26-61	— —	Trace	—	1.5 (22%)	1.4 (15%)	— —
9-9-61	— —	— —	—	1.0 (25%)	— —	— —
9-16-61	— —	Trace	—	Trace	— —	— —
9-22-61	— —	2.1 (32%)	1.7 (37%)	1.1 (30%)	— —	— —
9-30-61	— —	Trace	—	1.8 (15%)	.82 (27%)	— —
10-7-61	— —	3.8 (22%)	—	.45 (35%)	1.4 (17%)	— —
10-14-61	— —	Trace	—	.53 (25%)	1.6 (15%)	— —
10-21-61	— —	1.8 (20%)	—	1.2 (20%)	— —	— —
10-28-61	— —	1.1 (30%)	—	1.0 (32%)	1.3 (20%)	— —
11-4-61	— —	1.1 (30%)	—	—	1.2 (15%)	— —
11-11-61	— —	1.5 (37%)	—	Trace	—	— —
11-18-61	— —	1.0 (25%)	—	1.5 (25%)	Trace	— —
11-25-61	— —	—	2.0 (22%)	2.2 (35%)	1.3 (30%)	— —

— No Sample Collected.
Trace Net cpm equal to or less than background.

TABLE 8.—ENRICO FERMI REACTOR ENVIRONMENTAL BIOLOGICAL SAMPLES, GROSS BETA AND BARIUM-STRONTIUM ACTIVITY IN GRASS AND SOYBEANS

Collection Date	Grass				Soybeans			
	Gross β Activity		BaSr Activity		Gross β Activity		BaSr Activity	
	pc/gm grass	pc/gm ash	pc/gm grass	pc/gm ash	pc/gm grass	pc/gm ash	pc/gm grass	pc/gm ash
6-26-61	10	160						
	12	230						
	13	170						
	9	140						
7-31-61	15	170	Trace	Trace				
	8	120	"	"				
	20	200	"	"				
	11	120	"	"				
8-21-61	20	180	.032	.17	12	61	.13	1.2
	22	190	.063	.35	15	74	.20	1.6
	19	140	.12	.63	8.8	43	.18	1.3
	11	120			10	40	.13	.96
9-18-61	24	200	Trace	Trace			Trace	Trace
	25	170					"	"
	14	120	Trace	Trace			"	"
	30	210	"	"			"	"
10-9-61	8.3	80	Trace	Trace				
	300	2100	.12	.97				
	15	120	Trace	Trace				
	8.4	130	"	"				
10-30-61	24	240	Trace	Trace				
	21	160	.20	1.4				
	19	180	.067	.50				
	22	230	.084	.56				
11-20-61	31	320						
	38	380						
	37	350						
	66	680						
6-18-62	67	410			73	800		
	45	310			43	260		
	55	340			32	330		
	53	310						

TABLE 9.—BIG ROCK POINT REACTOR ENVIRONMENTAL BIOLOGICAL SAMPLES, GROSS BETA, BARIUM-STRONTIUM AND STRONTIUM-90 ACTIVITY IN GRASS

Final Collection Date	Gross β Activity		Barium-Strontium Activity		Strontium-90	
	pc/gm grass	pc/gm ash	pc/gm grass	pc/gm ash	pc/gm ash	pc/gm plant
7-1-61	22	180	Trace	Trace		
	14	200	"	"		
	18	190	"	"		
	14	170	"	"		
	11	160	"	"		
	11	140	"	"		
7-29-61	19	160	Trace	Trace		
	11	190	"	"		
	13	210	"	"		
	13	230	"	"		
	19	200	"	"		
	13	230	"	"		
9-2-61	5.9	190				
	7.8	250				
	21	85				
	21	180				
	15	170				
	12	170	--------	--------	10	0.6
9-30-61	37	480				
	17	400				
	29	290				
	32	360				
	37	270				
	30	280	--------	--------	7	0.6
10-28-61	200	2200				
	140	2700				
	180	1200				
	240	1600	--------	--------	4	0.4
	160	1300				
	180	1500				
11-25-61	230	5100	--------	--------	19	1.5
	220	4300	--------	--------	15	1.2
	270	3000	--------	--------	12	1.3
	300	2300	--------	--------	8	0.7
	290	3200				
	210	4500	--------	--------	10	1.2
6-6-62	--------	--------	--------	--------	18	1.2
					18	1.3
					22	1.1
7-14-62	--------	--------	--------	--------	26	0.9
					15	0.8
					24	1.2
					22	1.1
					29	1.5
8-11-62	--------	--------	--------	--------	34	1.7
					10	0.8
					27	1.3
					65	2.3
					37	1.9
9-8-62	--------	--------	--------	--------	56	1.2
					9	0.9
					71	2.9
					32	1.9

Summary

The Michigan Department of Health initiated an environmental surveillance program around the Enrico Fermi Power Reactor in 1958 and around the Big Rock Point Power Reactor in 1960. Environmental media sampled include air, rainwater, soil, field mice, and vegetation. Milk samples are collected from seven dairy plans around the State on a weekly basis. Two of the plants service the milksheds around Monroe and Charlevoix.

The initial program included four stations at the Enrico Fermi Power Reactor site and six stations around the Big Rock Point Reactor site as well as a station in Lansing. The results have demonstrated that the levels of radioactivity in media sampled since both plants became operational reflect only fluctuations in background radiation due to fallout and natural activity. Results are comparable in all three areas of the state. In the past 5 years, the program has satisfied its original objectives.

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(*3*) National Committee on Radiation Protection and Measurements: *Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air and Water for Occupational Exposure, National Bureau of Standards Handbook 69*, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (June 5, 1959).

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TABLE 10.—ENRICO FERMI ENVIRONMENTAL SOIL ACTIVITY, GROSS ACID SOLUBLE BETA ACTIVITY IN MICROCURIES PER GRAM OF DRY SOIL

[Limit of counting error at the 95% confidence level in parentheses]

Final collection date	Activity—μc/g (x10^{-6})			
	Station 1 Carleton	Station 2 Monroe	Station 3 Rockwood	Station 4 Reactor Site
5-18-59	2.5 (8%)	3.4 (6%)	3.3 (6%)	7.5 (4%)
6-8-59	4.4 (6%)	4.7 (5%)	2.8 (7%)	2.0 (8%)
8-24-59	1.0 (12%)	2.9 (7%)	2.6 (7%)	1.4 (10%)
9-21-59	3.4 (6%)	2.1 (8%)	1.4 (11%)	1.9 (9%)
10-27-59	7.7 (4%)	2.0 (8%)	2.5 (7%)	2.6 (7%)
11-23-59	1.5 (10%)	2.8 (7%)	2.7 (7%)	1.6 (10%)
1-11-60	2.1 (9%)	2.3 (8%)	1.9 (9%)	2.5 (8%)
2-8-60	3.0 (7%)	1.8 (9%)	3.3 (6%)	2.8 (7%)
3-14-60	1.4 (11%)	1.1 (12%)	0.91 (13%)	0.49 (19%)
4-4-60	1.9 (9%)	1.7 (9%)	2.3 (8%)	2.7 (7%)
5-16-60	1.5 (10%)	1.7 (9%)	1.7 (9%)	2.2 (8%)
6-20-60	1.3 (10%)	2.4 (7%)	2.4 (7%)	1.7 (9%)
7-25-60	1.5 (10%)	1.9 (9%)	1.2 (11%)	1.9 (9%)
8-15-60	1.1 (8%)	2.4 (6%)	1.4 (7%)	1.7 (7%)
9-19-60	1.3 (8%)	1.7 (7%)	1.2 (8%)	0.94 (9%)
10-24-60	1.5 (7%)	1.7 (7%)	1.1 (8%)	0.73 (11%)
11-21-60	1.2 (5%)	1.3 (6%)	1.4 (7%)	1.4 (7%)
12-12-60	1.3 (8%)	1.5 (7%)	1.3 (8%)	1.2 (8%)
1-16-61	1.0 (9%)	1.6 (7%)	1.4 (7%)	1.3 (8%)
6-26-61	1.7 (9%)	1.9 (9%)	2.5 (8%)	1.2 (11%)
7-31-61	1.2 (11%)	1.6 (9%)	1.8 (9%)	2.3 (8%)
8-21-61	1.4 (10%)	1.8 (9%)	2.2 (8%)	2.1 (8%)
9-18-61	1.6 (10%)	2.2 (8%)	3.4 (6%)	0.67 (16%)
10-9-61	1.4 (10%)	1.8 (9%)	3.2 (7%)	1.0 (12%)
10-30-61	1.3 (10%)	1.1 (12%)	2.3 (8%)	1.5 (10%)
11-20-61	1.7 (9%)	1.7 (9%)	1.5 (10%)	1.5 (10%)

TABLE 11.—BIG ROCK POINT REACTOR ENVIRONMENTAL SOIL ACTIVITY, GROSS ACID SOLUBLE BETA ACTIVITY EXPRESSED AS MICROCURIES PER GRAM OF DRY SOIL

[Limit of counting error at the 95% confidence level in parentheses]

Final date of collection	Activity —μc/gm (x10^{-6})			
	Station 1 Charlevoix	Station 2 Reactor Site	Station 3 Burgess	Station 4, 9 Mile Point
10-8-60	1.7 (11%)	1.5 (13%)	2.6 (12%)	1.8 (9%)
12-3-60	1.3 (9%)	0.96 (10%)	1.1 (7%)	1.7 (9%)

	Activity—μc/gm (x10^{-6})					
	Station 1 Charlevoix	Station 2 Reactor Site	Station 3 Burgess	Station 4 9 Mile Point	Station 5 5 Mile Creek	Station 6 Oyster Bay
7-1-61	0.63 (16%)	1.8 (9%)	2.3 (8%)	3.2 (7%)	1.6 (10%)	2.0 (8%)
7-29-61	1.2 (11%)	0.24 (32%)	0.77 (15%)	3.2 (7%)	2.1 (8%)	1.2 (11%)
9-2-61	2.3 (8%)	8.3 (4%)	2.1 (8%)	3.6 (6%)	2.8 (7%)	5.7 (5%)
9-30-61	2.4 (8%)	3.0 (7%)	1.8 (9%)	4.9 (5%)	2.1 (8%)	4.2 (6%)
10-28-61	1.7 (7%)	1.1 (10%)	2.2 (8%)	1.9 (8%)	2.0 (7%)	2.5 (6%)
11-25-61	2.6 (9%)	1.5 (12%)	2.1 (8%)	2.4 (9%)	2.7 (8%)	3.4 (7%)

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors periodic reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC installations have appeared periodically in *RHD* since November 1960. Following are reports for Oak Ridge Area and Hanford Atomic Products Operation.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set forth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are identical to those published in the Federal Register (*1*).

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1. Hanford Atomic Products Operation[1]
Calendar Year 1963

General Electric Company
Richland, Washington

An evaluation of results obtained from the Hanford environmental surveillance program for 1963 indicates that most of the environmental radiation exposure for the majority of persons in the neighborhood of the Hanford project was due to natural sources and worldwide fallout rather than to Hanford operations.

Of the low-level wastes released to the environment from the Hanford plants, neutron-induced radionuclides present in reactor cooling water discharged to the Columbia River continued to be the source of greatest potential exposure to the people in the environs. The primary mechanisms of exposure from this source are drinking water derived from the river and consumption of fish and waterfowl which inhabit the river.

The city of Richland started using the Columbia River as a source of sanitary water during 1963. In the 4 months following startup of the new plant in August, this source contributed a total exposure amounting to about 5 percent of the annual permissible limit for populations. The gastrointestinal tract is the limiting organ for the mixture of nuclides present in drinking water pumped from the Columbia River. In Pasco and Kennewick, which are further downriver, the estimated exposures from drinking water were respectively about 5 percent and 1 percent of the GI tract limit (population at large) for the full 12 months of 1963. The only persons who received radiation exposures attributable to Hanford that were greater than those resulting from the drinking water were the people that ate local fish or waterfowl or who regularly consumed produce from nearby farms irrigated with water pumped from the Columbia River below the reactors.

The highly unlikely, but conceivable, combination of circumstances that would result in the greatest exposure to an individual from the radionuclides released by the Hanford plants is postulated as; (1) the consumption of some 200 meals of locally-caught fish during the year, (2) the consumption of meat, milk, fruit, and vegetables from irrigated farms of the Riverview district, and (3) the drinking of water from the Pasco system. An individual with such habits could conceivably take in enough radioactive material of Hanford origin (mostly P^{32}) to supply about 45 percent of the annual permissible amount. In this case the bone is the organ that is most restrictive. This same individual could also take in enough Sr^{90} of the world-wide fallout origin to equal about 5 percent of the permissible amount—more than twice that estimated for 1962. The exposures from nuclides of Hanford origin and from fallout are not additive in relation to limits, however, since the Radiation Protection Guides recommended by the Federal Radiation Council are not applicable to fallout from weapons tests.

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[1] Summarized from Hanford Atomic Products Operation, *Evaluation of Radiological Conditions in the Vicinity of Hanford for 1963*, HW-80991, February 24, 1964.

The amount of I^{131} in the Hanford environs was substantially less than in the previous 2 years when extensive testing of weapons was in progress. Nevertheless, worldwide fallout continued to be the dominant source of the I^{131} found locally, except for the month of September when abnormally large amounts were released from one of the chemical separations plants. For the calendar year 1963, the I^{131} in milk from local farms could have resulted in radiation exposures to the thyroids of infants of approximately 10 percent of the Federal Radiation Council Radiation Protection Guide.

The Hanford project is located in a semiarid region of southeastern Washington having an average annual rainfall of about 7 inches. Natural vegetation in this section of the state is sparse and primarily suited for grazing, although large areas near the project perimeter have gradually been put under irrigation during the past few years. The plant site comprises an area of about 500 square miles. The Columbia River flows through the project and forms part of the eastern boundary. The meteorology of the region is typical of a desert area; frequent strong inversions occur at night and break during the day to provide unstable and turbulent conditions. Near the plant production sites the prevailing winds are from the northwest with strong drainage and cross winds causing distorted flow patterns.

The populated areas of primary interest near the plant perimeter are Richmond, Pasco, and Kennewick. Smaller communities in the vicinity are Benton City, West Richland, Mesa, and Othello. All together about 80,000 people live in the vicinity of the project. Protection of these people from undue radiation exposure attributable to Hanford sources is one of the attendant responsibilities in the operation of the Hanford facilities.

During the course of operating the nuclear reactors, fuel fabrication plants, chemical separation plants and research and development laboratories, various radioactive wastes are generated. High level wastes are concentrated and retained in storage within the project area. Controlled releases of low-level wastes, for which concentration and retention are not feasible, are made to the ground. The Hanford practices governing radioactive waste disposal are described in the Hearings on Industrial Radioactive Waste Disposal held by the Joint Congressional Committee on Atomic Energy in 1959.

The Atomic Energy Commission Manual Chapters (*3*), the recommendations of the National Committee on Radiation Protection and Measurement (NCRP) (*4*), the International Commission on Radiological Protection (ICRP) (*5*), the Federal Radiation Council (FRC) (*6*) and the results of Hanford research programs form the basis of radiation protection practices at Hanford. The recommendations of these organizations in the form of permissible rates of intake of specific nuclides and guides for radiation exposure constitute criteria against which radiation exposures estimated from measurements of the Hanford environmental surveillance program are compared. The results of this comparison indicate the effectiveness of Hanford waste control and radiation protection practices and point out any conditions requiring attention.

This report estimates the annual exposure received by the individuals who are expected to receive the greatest amount of radiation from environmental sources, and the exposure received by people who are more typical residents of this region. These exposures are compared with the recommendations of the NCRP and FRC. The NCRP recommendations, in the form of maximum permissible exposures for

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individuals that are not employed in radiation work, are 1,500 mrems per year to the GI tract, 500 mrems per year to the total body, and 3,000 mrems to the thyroid. The limits for bone-seekers are calculated with reference to biological effects observed from deposition of radium and are most readily applied in the form of maximum permissible rates of intake (MPRI).[2] Similar evaluations for previous years have also been reported (*2,7,8*). The Radiation Protection Guides established by the FRC for individuals are 1,500 mrems per year to the thyroid, 1,500 mrems per year to the bone, and 50 mrems to the whole body. The Radiation Protection Guides for the "average of a suitable sample of an exposed population group" are one-third of those for individuals.

ENVIRONMENTAL CONDITIONS

A discussion and interpretation of the results of the various Hanford environmental sampling programs are presented in the following text and tables.

Radionuclides in the Columbia River

Hanford's eight production reactors are cooled with Columbia River water. This water goes through filtration processes and then passes once through the reactors as a coolant before being returned to the river. Stable elements present in the cooling water are transformed into radionuclides during passage through the reactors, and radioactive materials formed on the surfaces of the fuel elements and channels are washed away by the cooling water.

Many of the radionuclides formed in reactor cooling water are short-lived and decay rapidly after formation. In addition to radioactive decay, some portion of the radionuclides is removed from the water by sedimentation and uptake by aquatic organisms. The radionuclides in the river also include some contribution of "fallout" from weapons tests.

Samples of river water were obtained every 2 weeks from Vernita Ferry, Hanford Ferry, 300 Area, the inlet to the Pasco municipal water plant, and Vancouver. Some samples of river water were also collected at Richland, particularly during the latter part of the year when the new water plant was in operation. The average concentrations of radionuclides measured routinely at the four river sampling stations are shown in table 1.

TABLE 1.—ANNUAL AVERAGE CONCENTRATIONS OF SELECTED RADIONUCLIDES IN COLUMBIA RIVER WATER, 1963

[pc/liter]

Radionuclide	Hanford Ferry	Richland	Pasco	Vancouver
Total Beta	52,000	23,000	11,000	500
RE+Y [1]	1,800	640	440	—
Na^{24}	7,700	3,400	1,600	—
P^{32}	340	260	190	30
Cr^{51}	12,000	8,800	6,700	2,600
Mn^{56}	9,800	—	—	—
Cu^{64}	17,000	5,900	2,300	—
Zn^{65}	470	380	220	60
As^{76}	2,400	1,200	750	—
Sr^{90}	1	1	1	1
I^{131}	12	8	8	4
Np^{239}	3,300	2,100	1,600	—

[1] Rare earths plus yttrium.

The Hanford Ferry monitoring station is about 7 miles downstream from the closest production reactor and about 6 miles upstream from the point where the project boundary crosses the Columbia River. Studies of effluent distribution at the Hanford Ferry indicate nonuniformity which causes sample results to show higher concentrations of most radionuclides than the average of the cross section at this location. Measurements on a traverse across the river at Richland indicated a fairly uniform distribution of the longer-lived radiosotopes throughout the river at this point. At Pasco, the distribution of radiosotopes in the river is slightly nonuniform because of the entry of the Yakima River some 10 miles upstream.

Vancouver, about 260 miles from the reactors, is the farthest downstream location where river water is routinely sampled for Hanford's surveillance program. Further downstream the intrusion of sea water into the Columbia River complicates quantitative measurement of the radionuclides.

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[2] The MPRI is taken as the maximum permissible concentration in water for a given radionuclide, as recommended by the NCRP for persons in the neighborhood of controlled areas, multiplied by the rate of water intake as defined for the standard man. This amounts to one-tenth of the MPC's for continuous exposure of occupational workers multiplied by 2200 cc per day, or by 800 liters per year in the case of annual estimates.

Radiation exposure that results from the drinking of water pumped from the river and sent through treatment plants is discussed in the next section of this report. There is no known instance of untreated river water being consumed routinely by humans. For comparative purposes, however, the relationship between the concentrations of radionuclides in the untreated Columbia River water and published values for maximum permissible concentrations in water is shown in table 2. In this case the comparison is with the MPC's listed in Column 2, Table II of Annex I of AEC Manual Chapter Appendix 0524 (*3*). For the most part these MPC's are equivalent to one-tenth of the most limiting values recommended by the NCRP (*4*) for occupational workers. The marked reduction in percent of MPC_w that occurs with distance downstream from the reactors results principally from radioactive decay of the shorter-lived nuclides.

TABLE 2.—RELATIONSHIP BETWEEN THE CONCENTRATIONS OF RADIONUCLIDES IN UNTREATED COLUMBIA RIVER WATER AND MAXIMUM PERMISSILBE CONCENTRATIONS

Sampling location	% of MPC [1]
Hanford	34
Richland	17
Pasco	12
Vancouver	2

[1] This is a summation of the percentages of MPC's contributed by the several individual radionuclides measured routinely in the river water. The MPC's used and the method of summation are taken from AEC Manual Chapter 0524 (3).

Radionuclides in Drinking Water

In the latter part of 1963, Richland started up a new water treatment plant that draws water from the Columbia River. Previously Richland obtained its water from wells, and Kennewick and Pasco (downstream from Richland) were the nearest cities to the Hanford reactors that used Columbia River water. Sanitary water was collected at the Richland and Pasco water treatment plants every 2 weeks and analyzed for the important radionuclides. Similar analyses were made on Kennewick water once each month. The results of the radioanalysis of water from these plants are summarized in table 3.

TABLE 3.—ANNUAL AVERAGE CONCENTRATION OF SELECTED RADIONUCLIDES MEASURED IN SANITARY WATER, 1963

[pc/liter]

Radionuclide	Richland [1]	Pasco	Kennewick
Total Beta	23,000	4,000	600
RE+Y [2]	90	50	10
Na^{24}	3,000	600	90
P^{32}	130	40	<10
Cr^{51}	14,000	5,400	2,500
Cu^{64}	3,000	400	90
Zn^{65}	80	90	<20
As^{76}	800	200	<60
Sr^{90}	2	1	<0.5
I^{131}	10	5	<3
Np^{239}	2,500	800	30

[1] Averages for Richland are based only on the last quarter of 1963 when the new water treatment plant was in full operation. These averages may change significantly when a full year's operation is used.
[2] Rare earths plus yttrium.

The concentrations of short-lived radionuclides in the water at the time it is consumed is less than shown in the table because there is a significant flow time between the water plant and most consumers. The flow time may vary from hours to day depending upon the location of the customer on the distribution system.

Table 4 shows the removal of several radionuclides by the water treatment at Pasco and Richland. These data include the radioactive decay of the short-lived radionuclides during travel through the water treatment plant.

TABLE 4.—DEPLETION OF RADIONUCLIDES FROM COLUMBIA RIVER WATER BY TREATMENT AT THE RICHLAND AND PASCO WATER PLANTS, 1963

Radionuclide	% Depletion	
	Pasco	Richland
RE+Y [1]	90	80
Cu^{64}	80	40
P^{32}	80	50
As^{76}	80	40
Na^{24}	60	15
Zn^{65}	60	80
Np^{239}	50	—
Cr^{51}	20	—

[1] Rare earths plus yttrium

The calculated annual average dose to the GI tract, total body and the percentage MPRI for bone from sustained consumption of sanitary water at the three cities is presented in table 5.

The thyroid dose shown in table 5 for Pasco residents includes an increment accrued from fission products released by an unusually severe failure of a fuel element in one of the reactors

TABLE 5.—CALCULATED ANNUAL DOSE FOR SELECTED ORGANS FROM ROUTINE INGESTION OF SANITARY WATER [1], 1963

Location	Total body mrem	GI tract mrem	Bone % MPRI	Thyroid (small child) mrem
Richland [3]	1	25	0.8	22
Pasco	1.5	20	0.9	40
Kennewick	<1	<5	<0.5	<20

[1] Here and elsewhere in this report where a dose from an ingested nuclide is expressed in mrem units, the determination is made from parameters used by the ICRP to translate dose rates into Maximum Permissible Concentrations for drinking water. In most cases the estimated annual intakes of individual radionuclides were multiplied by conversion factors derived from the ICRP parameters and published by Vennart, *et al.* (*9*).

The "standard man" (*5*) beverage intake of 1.2 liters per day was used in this calculation. This departure from the 2.2 liters per day (total liquid intake for the "standard man" including foods) used for similar calculations in the past more reasonably represents the average exposure from drinking water alone.

[3] The radiation dose shown in this table for Richland residents was all accrued during the last 4 months of 1963 subsequent to the change from wells to Columbia River water.

that occurred on May 12, 1963. Fuel element failures are not unusual but the quantities of fission products released to the river from them are ordinarily small. During 1963, only the one on May 12 released enough fission products to warrant special evaluation. For estimating thyroid dose, a small child was considered to have consumed 1 liter of water from the Pasco supply during the time when the maximum concentration of I^{131} was present. The resulting dose to the child's thyroid would have been approximately 8 mrems. This would have increased his dose from about 6 percent of the FRC Radiation Protection Guide for an exposed population group to about 8 percent. The dose to the GI tract, bone and total body from this incident was negligible (*10*).

The dose received by the GI tract of Pasco residents continued at about the same level as experienced in 1962. Treatment of the reactor cooling water for reduction of As^{76}, Np^{239}, and other nuclides was continued during 1963. This modification consisted mainly of increased addition of alum in the clarifying process which reduced the amount of parent materials from which As^{76} and Np^{239} are formed.

Radionuclides in Fish and Waterfowl

Fish and waterfowl that feed in the Columbia River downstream from the reactors acquire some radionuclides that enter the river with the reactor effluent water. Except for suckers, whitefish usually contain the greatest concentration of radioactive materials; P^{32} is the radionuclide of greatest significance. Seasonal variation is affected by the amount of P^{32} released from the reactors, the feeding habits and metabolism of the fish, and flow rate of the river which determines the effective dilution of the reactor effluent. The concentration of P^{32} in whitefish starts to decrease late in the year and, due to cold water and limited feeding, continues to decrease until spring. As the temperature of the river water rises in the spring, the fish eat larger quantities of food organisms that have accumulated P^{32} and this results in an increased deposition of P^{32} in the fish. The trend is reversed in mid-spring by the high flow rates of the Columbia which afford greater dilution of effluent and thus lower concentrations of P^{32} in the food organisms. As the high flows recede in early summer and water temperatures rise further, the P^{32} content in fish again increases and reaches a maximum in late fall. The average concentration of P^{32} in whitefish sampled downstream from the reactors during 1963 was 420 pc/g of flesh, and the sample with the highest concentration contained 2,800 pc/g. The annual average Zn^{65} concentration in whitefish was 38 pc/g of flesh and the maximum was 120 pc/g in samples collected at Ringold. If whitefish were eaten at the rate of one meal per week (about 25 lb/year), the intake in 1963 would have been approximately 4.8 μc of P^{32} and 0.43 μc of Zn^{65}. The resulting exposure would have been about 100 mrems to the GI tract, 40 mrems to the total body, and 30 percent of the MPRI for bone.

In order to determine the consumption of locally caught fish more accurately, a number of fishermen were asked to estimate the quantities and kinds of fish they ate each year. This survey was carried out by personnel of the State of Washington, Department of Game. The data obtained thus far show that the individuals who probably ingest the largest amounts of P^{32} are fishermen who claim to eat bass, crappie, perch, and catfish at a frequency of 3 to 5 times a week. This number of fish meals implies an annual consumption of about 90 lb (in contrast with the 25 lb of whitefish used as a reference amount in the preceding paragraph), but the average P^{32} content of the species involved is lower than in the whitefish. An intake of 7 μc of P^{32} during 1963 is estimated for an individual that claimed to eat some 200 meals of fresh fish caught from the Burbank Area.

People who eat local fish ingest Zn^{65} along with the P^{32}. The exposure that results from the Zn^{65} is very small but because it is a gamma emitter, its presence in the body can be detected by whole body counting techniques. (Small amounts of P^{32} in the body cannot be measured accurately because P^{32} emits only beta particles.) A few fishermen have been counted in the Hanford Whole Body Counter and the amounts of Zn^{65} detected were much smaller than expected on the basis of their estimated fish consumption. Such results suggest that fishermen tend to over-estimate their fish consumption and, therefore, that calculations of P^{32} intake based on such estimates yield values that are substantially higher than actually occurred.

Migratory waterfowl, such as mallard ducks and Canada geese, that have utilized the Hanford section of the river may also contain P^{32} and Zn^{65}. Hunters from Washington contributed samples from 299 ducks bagged during the 1963 hunting season. Results of radioassay of these samples and of 186 ducks collected from swamps and ponds within the project boundaries showed that, of all the ducks contributed by hunters, only 22 contained concentrations of P^{32} greater than the detectable level of 50 pc/g of flesh (wet weight) and only one was greater than 500 pc/g (540 pc/g). About one-half of the ducks collected within the project boundary contained detectable amounts of P^{32}, and 37 of these ducks contained greater than 500 pc P^{32}/g. The maximum concentration found was 4,800 pc/g of flesh.

Radionuclides in Marine Organisms

Zn^{65} and P^{32} are the only radionuclides of reactor effluent origin found in sufficient abundance beyond the mouth of the Columbia River to be of radiological interest. Oysters have been found to contain higher concentrations of Zn^{65} than other common sea food organisms. The average concentrations in 26 samples (a total of 52 lb) of oysters taken periodically throughout the year were 80 pc Zn^{65}/g and 4 pc P^{32}/g. Consumption of oysters containing these concentrations of Zn^{65} and P^{32} at a sustained rate of one meal per week (½ lb) would lead to an annual exposure of about 9 mrems to the GI tract, 6 mrems to the total body, and less than 0.5/percent of the MPRI for bone.

Radionuclides in the Atmosphere

At Hanford, gaseous waste is released to the atmosphere through 200-foot high stacks after removal of some 99 percent of the radioactive materials present. These radioactive materials are primarily associated with process vessel off-gases from the chemical separations facilities. Under normal operating conditions, the ventilation air from laboratory and reactor buildings contains comparatively minor amounts of radioactive materials.

Iodine–131 is the radionuclide of principal interest in the separations facilties process off-gases. During 1963 the annual average emission rate of I^{131} from the separations plant stacks was 0.38 curie per day. Monitoring for other specific radioisotopes was discontinued in 1963 because previous measurements had shown insignificant emission rates. Gross beta measurements are now made continuously to detect any change in emission rates of these other radionuclides. The results for the past 3 years are summarized in table 6. The fission product recovery facilities operating at Hanford contributed negligible amounts of radionuclides to the environs during 1963. The average emission rate of Sr^{90} from such facilities was less than 0.0018 curie per day.

TABLE 6.—ANNUAL AVERAGE EMISSION RATES OF SELECTED RADIONUCLIDES FROM SEPARATIONS PLANT STACKS

[curies/day]

Radionuclide	1963	1962	1961
I^{131}	0.38	0.35	0.7
$Zr\text{-}Nb^{95}$	—	0.0024	0.005
Ru^{103}	—	0.0009	0.003
Ru^{106}	—	0.0036	0.005
Ce^{141}	—	0.0002	0.006
Ce^{144}	—	0.015	0.01
Filterable gross beta	0.013	—	—

Measurements of air-borne I^{131} were made routinely at several locations within the Hanford reservation and at several locations adjacent to the plant. Results for the past few years are summarized in table 7.

The four locations listed in table 7 lie within a 45-degree sector southeast to south of the separations centers.

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TABLE 7.—AVERAGE IODINE-131 CONCENTRATIONS IN THE ATMOSPHERE

[pc/m³]

Location	Distance from separation stacks miles	1963	1962	1961	1960
Benton City	20	0.03	0.08	0.02	0.05
North Richland [1]	20	—	0.10	0.04	0.04
Richland	23	0.02	0.04	0.02	0.03
Pasco	32	0.02	0.08	0.04	0.02

[1] The North Richland sampling location was discontinued in October 1963. A new sampling location was installed at the Prosser Barricade which lies in the same direction from the separations areas but is about 6 miles closer.

The annual average I^{131} concentrations in air during 1963 returned to the levels observed in 1961 prior to resumption of nuclear testing by the USSR. The long-term average release closely approximated the restrictive local operation guides until early September when an unplanned release of I^{131} occurred from a chemical separations facility. Early recognition of the abnormal conditon and immediate action successfully retained a major portion of the I^{131} within the plant. The concentration of I^{131} measured in air about the plant perimeter increased temporarily, but this did not significantly affect the longer-range annual exposure from inspired air. Measurement of I^{131} in air at locations about the plant perimeter indicated the average concentration during 1963 was less than 0.05 pc/m³. If such a concentration were sustained in inspired air, the resulting annual dose to the thyroid of the "standard man" would be less than 1 mrem.

Radionuclides in Milk and Agricultural Produce

The radioactivity in locally grown agricultural produce can be influenced by deposition of air-borne radionuclides, or by irrigation with water containing reactor effluent radionuclides. Chemical separations facilities are generally considered to be the principal local source of air-borne radionuclides. Under certain conditions, ventilation stacks of the reactors or laboratory facilities could possibly become of some small interest. The closest farming area to the separations facilities is about 13 miles away, and under most meteorological conditions this distance affords adequate dilution before the radioactive effluents reach the farming areas.

Most of the irrigated farm land near the Hanford plant uses water from the Yakima River, or from the Columbia River above the project. However, the Ringold farms and the Riverview district west of Pasco, which are about 15 and 30 miles downstream from the reactors, respectively, take water from the Columbia River for irrigation. Some of the reactor effluent radionuclides can be traced through the irrigation water to milk and other farm products. The Ringold farms, approximately 13 miles east of the production areas, involve about 20 people working some 500 acres of land with fruit as their principal product. The Riverview farm area has about 30 families that raise fruit, vegetables, beef, and dairy herds. This area is located about 30 miles southeast of chemical separations plants. Another agricultural area near the project is Benton City, located on the Yakima River about 20 miles directly south of the separations facilities.

Surveillance of the milk available to people living near the Hanford plants included samples from local farms and dairies and samples of commercial supplies sold in local stores. The concentrations of radionuclides found in the milk sold by stores was similar to that reported by the U. S. Public Health Service and the Washington State Department of Health (*11*) Milk from farms irrigated with water pumped from the Columbia River downstream from the reactors contained P^{32} and Zn^{65} as well as the fission products of fallout origin.

The Sr^{90} concentration in milk known to be of local origin ranged from less than 2 to 21 pc/liter. Such values are similar to concentrations found in commercial milk produced in areas that could not be affected by the Hanford plants. The average concentration of Sr^{90} in milk produced in the Hanford environs during 1963 was about 13 pc/liter, which is among the lowest concentrations in the nation. A temporary increase in Sr^{90} was noted during the spring as a result of the seasonal influx of world-wide fallout. Concentrations of Sr^{89} and Cs^{137} in milk analyzed at Hanford were generally below the detection level of 4 pc Sr^{89}/liter. and 30 pc Cs^{137}/liter. World-wide fallout is the principal source of these radionuclides in milk.

Measurements for I^{131} were made on all milk samples collected in 1963. The results of these measurements indicate that during the early part of the year, I^{131} concentrations were well below 10 pc/liter, and were following a generally decreasing trend. The maximum concentration of iodine–131 found in milk during the first half of the year was 84 pc/liter on June 19, 1963. This maximum value occurred at the same time as the peak of the influx of world-wide fallout, but this was probably a coincidence. However, releases of iodine–131 from Hanford facilities were not sufficient to account for the observed levels in milk at this time. Following this peak, concentrations declined rapidly to 10 pc/liter or less.

In early September, I^{131} concentrations in milk again increased as a result of the inadvertent release of I^{131} from a separations plant previously described. The milk sampling program was increased in September and October and the maximum concentration actually measured was 140 pc I^{131}/liter in a sample collected in the West Richland-Benton City area. It was estimated that the highest thyroid dose resulting from the I^{131} release was probably received by a small child residing at the farm where the maximum milk results were obtained. By assuming a 4-gram thyroid for a 4-year old child and consumption of 1 liter of milk per day produced at the farm, it was estimated that the maximum thyroid dose during the 3-month period following the incident did not exceed 30 mrems. A whole body counter measurement of this child's thyroid in October 1963 confirmed the estimated thyroid burden of I^{131}. The value of 30 mrems can be compared with the FRC Radiation Protection Guide for individuals of 1,500 mrems per year.

Columbia River water removed below the reactors for irrigation is a source of P^{32} and Zn^{65} in milk at dairy farms in the Riverview and Ringold areas. The average concentrations of Zn^{65} in milk from the Riverview-Ringold area during 1963 was about 600 pc/liter and the concentration of P^{32} was about 800 pc/liter Zn^{65} or P^{32} are usually not detected in milk that is distributed through commercial outlets in the Tri-City area because such milk is not usually obtained from areas irrigated with water obtained from the Columbia River below the reactors.

At a consumption rate of 1 liter of milk per day the "fallout" radionuclides would contribute an average annual dose of less than 1 mrem to the GI tract, about 8 mrems to the total body, and about 7 percent of the FRC rate of intake guide for bone.[3] Those residents who drink milk obtained locally from the Ringold and Riverview areas would receive some additional exposure from P^{32} and Zn^{65} amounting to about 8 mrems to the GI tract, 3 mrems to the total body, and about 2 percent of the MPRI for bone.

Analyses of miscellaneous fresh produce purchased during the 1963 growing season from local farms and markets substantiated prior experience that only small quantities of radionuclides are present in locally grown produce under normal plant operating conditions.

The average concentration of I^{131} measured on samples of leafy vegetables collected from local farms and vegetable markets during the period of May through September was less than or approximately equivalent to the detection level of 0.05 pc/g. Considering a consumption rate of 100 g of leafy vegetables per day throughout the 5 month growing season, the average annual intake from local vegetables would be about 750 pc I^{131}. Such an intake implies an annual exposure of about 1 mrem to the thyroid of a "standard man".

Concentrations of I^{131} in Cattle Thyroids

The collection of thyroids from cattle slaughtered at Pasco was initiated in 1960 and then broadened in 1962 to include collection of thyroids of cattle slaughtered at Moses Lake, Toppenish, Walla Walla, and Wenatchee. Since the concentration of I^{131} in bovine thyroids is about 2 orders of magnitude higher than that in the pasture grass or in milk, it is advantageous to use thyroid measurements to follow probable trends in concentrations of I^{131} in milk and farm produce when the levels in milk and vegetables are too low for practical measurement. The sensitivity of cattle thyroids is evident from the significant increase in I^{131} concentrations observed for a short period in September following the unplanned release of I^{131} from one of the chemical separations facilities. The maximum concentration, however, was only 62 pc/g, which was considerably less than levels observed in late 1962 and early 1963 as a result of I^{131} from fallout.

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[3] The Federal Radiation Council does not consider fallout from the testing of weapons to be from "normal peacetime operations" and thus subject to Radiation Protection Guides applicable to industry.

Radioactive Particulates in the Atmosphere

Air sampling stations are maintained at several locations within the Hanford reservation and at several sites throughout the Pacific Northwest. Sample filters are changed weekly by cooperating agencies at Seattle, Spokane, Walla Walla, and Yakima in Washington; Meacham and Klamath Falls in Oregon; Boise and Lewiston in Idaho; and Great Falls, Montana. These filters are sent to Hanford where they are analyzed for total beta activity.

During the early part of 1963, the activity observed on air filters remained at nearly the level measured following USSR nuclear testing in the fall of 1962. Two peak activity periods occurred, one in February and one in May, indicating an influx of world-wide fallout. Analysis of the May activity, the highest since the fall of 1961, indicated the material was approximately 1 year old. In August a very rapid decline in concentrations occurred and by October the level was about 1 pc β/m^3.

Results of air filter samples are not used in estimating exposure but serve to illustrate the trends in atmospheric contamination. Sudden changes in concentrations are used to signal the need for shifted emphasis in other portions of the environmental monitoring program related to atmospheric contamination.

External Radiation

Measurements with ionization chambers stationed above the ground and submerged in the Columbia River were used to estimate the combined exposure from external sources in the vicinity of the Hanford project. Measurements over the ground indicated that the annual exposure for 1963 was about 170 mr, essentially the same as measured during 1962. Virtually all of this radiation originates from natural background and world-wide fallout from nuclear testing, and any additional contribution from Hanford sources is not readily discernible. Background measurements were relatively low during the first part of the year, and then increased during the latter half of the year.

Immersion dose measurements were obtained with pocket-type ionization chambers submerged 2 to 5 feet below the surface of the Columbia River. Exposure rates in the river are higher than those measured over land because of the presence of gamma emitters, especially Na^{24}, from reactor effluent. Near Richland and Pasco the average dose rates measured in the river during the months of April through October were about 2 and 1.5 mr per day, respectively. Further upsteam near the laboratories area the dose rate was 3 mr per day. A person swimming or boating in the river for 240 hours during the year would receive about 20 mr total body exposure in the vicinity of Richland and about 15 mr near Pasco.

At the river shoreline radiation measurements indicated the dose rate was about 0.25 mr/hour from radionuclides deposited with debris and in the mud and sand by the fluctuating water level. An ardent fisherman spending 6 hours per week, 8 months of the year, along the river bank in the vicinity of Richland would receive an annual whole body exposure of about 50 mr.

Radioactive Wastes Released to Ground

Liquid wastes from the Chemical Separations areas are routed to various facilities dependent upon their burden of radionuclides. High level wastes, normally containing concentrations greater than 100 $\mu c/cc$, are stored in concrete tanks lined with steel. Intermediate level wastes, ordinarily containing concentrations in the range of 5 x 10^{-5} $\mu c/cc$ to 100 $\mu c/cc$, are sent to underground "cribs" from which they percolate into the soil. Low level wastes, usually containing less than 5 x 10^{-5} $\mu c/cc$, are sent to depressions in the ground where surface ponds or "swamps" have been formed as a result of the continuous addition of relatively large volumes. The areas selected for liquid waste disposal have soil with good ion exchange capacity and depths of 150 to 350 feet to ground water.

One important objective in the management of wastes placed in the ground is the prevention of radiologically important radionuclides from reaching the ground water in quantities that could ultimately cause significant human exposure should they migrate to the Columbia River.

For this reason wells have been drilled in and around crib and tank storage areas to detect any leaks in the tanks and for measuring radionuclides that have reached the ground water. Virtually all of the radionuclides present in the ground water have been introduced with liquids sent to the cribs.

The quantity of radioactive materials sent to ground during 1963 (excluding tritium and the materials sent to the storage tanks) was about 36,000 curies. This did not significantly change the historical total which is estimated to be 2.6 x 10^6 curies. Because of radioactive decay, the current total in the ground is estimated as 2.6 x 10^5 curies. In order of abundance, the bulk of this material is Ru^{106}, Cs^{137}, and Sr^{90}.

The detectable beta contamination (not including tritium) in the ground water beneath the 200-W Area was less extensive in 1963 than in previous years. This resulted because of a reduction in the amount of contaminants discharged to ground, radioactive decay, and further dilution in the ground water.

A substantial amount of tritium has been sent to the ground with the intermediate level liquid wastes from the separations plant. In all probability some tritium and Ru^{106} originating at the chemical processing areas is now entering the Columbia River. However, the contribution of these nuclides is too small to be detectable in the river water and any exposure from them is negligible.

RADIATION EXPOSURE

The total radiation dose that is received from environmental sources differs substantially between individuals because their food and beverages come from various supplies, because the kinds and quantities consumed are subject to individual preference, because some people do more swimming, fishing, and boating than others, and because of other personal habits. These inherent variations between individuals require a somewhat subjective approach to the question of probable total exposure in relation to various limits. The Federal Radiation Council has provided two sets of guides against which exposures from environmental sources can be judged, *viz.* one for the individuals that receive the greatest exposure, the other for the average exposure received by an exposed population (taken as one-third that set for individuals). For the Hanford environs, possible exposures from the various sources described in the preceding sections have been combined in two ways to allow comparisons with both the individual and population guides. In one case a hypothetical, but plausible, individual has been assigned dietary and other habits that would result in what would seem to be the greatest rational exposure. As a second case, an exposure has been estimated for the "average" Tri-City resident. Several hundreds (perhaps a few thousands) of people receive more exposure than calculated for the "average" Tri-City resident but very few, (and quite possibly none) receive as much as that calculated for the "maximum" individual. Included in the intermediate group are the families that subsist largely on foodstuffs produced on farms irrigated with water taken from the Columbia River downstream from the plants.

The Maximum Individual

Attempts are being made to identify the individuals that actually receive the greatest exposure. Such individuals are undoubtedly persons that frequently eat fish caught locally in the Columbia River and produce grown on farms irrigated with Columbia River water. During the past 2 years, over 600 fishermen have been questioned by employees of the State of Washington Department of Game on their consumption of fish. The greatest consumption reported was about 200 meals per year, consisting dominantly of crappie, perch, bass, and catfish, caught near Burbank. On the basis of radiochemical analyses of such fish caught in this area, the intake of P^{32} for this individual during 1963 would have amounted to about 7 μc (about 45 percent of the NCRP limit). Whether the individual actually ate that much fish is not confirmed. Some other persons reporting unusually high consumption of local fish have been counted in the Whole Body Counter and contained far less Zn^{65} than predicted on the basis of their estimates of the quantities of fish eaten.

The reported consumption of 200 meals of local fish per year is used as a basis for calculating the maximum intake of radionuclides from this source. If this same individual is also assumed to consume each day over 2 qts. of water from the Pasco system, and about 1 qt.

of milk, ½ lb. of beef, and nearly ½ lb. of fresh leafy vegetables (in season), all produced on irrigated farms of the Rivierview District, the composite exposure from these sources amounts to about 15 percent of the appropriate limit for the GI tract, 50 percent of the limit for the bone, 1 percent of the limit for the thyroid, and 25 percent of the limit for the total body. The estimated exposure to the total body includes an increment of 50 mr received from the river bank while catching the fish. It also includes a contribution from ingested Sr^{90} that is unrealistically high (20 mrems) in relation to 1 year's intake, because it assumes an accumulation of Sr^{90} in the body that would only be gained over several decades.

The maximum thyroid dose is postulated to have occurred in a small child, rather than an adult, because of the relatively small mass (2 g versus 20 g for an adult) in which the ingested I^{131} accumulates.[4] On the basis of a daily intake of 1 liter of milk from a farm of the Riverview District, 0.8 liter of water from the Pasco system, and 50 g of fresh leafy vegetables, the intake of I^{131} for the year is estimated at about 6,700 pc, which would deliver a dose of about 115 mrems—about 7.5 percent of Radiation Protection Guide for individuals.

The Average Tri-City Resident

The vast majority of people who live in Richland, Pasco, and Kennewick obtain their food from local stores (rather than directly from farms) and do not eat fish caught from the Columbia River. The principal sources of radionuclides to these people are world-wide fallout (present to some extent in nearly all foodstuffs throughout the country) and drinking water pumped from the Columbia River.

The contribtuion from fallout is almost entirely associated with Sr^{90} and I^{131} and is assumed to be the same for all three cities. The Sr^{90} intake is estimated from dietary surveys made elsewhere in the United States and reported by the Federal Radiation Council (*6*) but adjusted on the basis of the Sr^{90} content of milk sold in local stores during 1963. The result is about 0.01 μc for the year, which would be about 15 percent of the FRC guide for a population exposed to Sr^{90} from a normal peacetime source.

The contribution from nuclides of Hanford origin in drinking water is substantially different for the three cities as discussed earlier. The dose to the GI tract was greater in Richland than in the cities further downriver because of a greater abundance of the short-lived nuclides. As shown previously in table 5, the exposure accrued during the last 4 months of 1963 is estimated at about 25 mrems—about 5% of the population limit. The value is expected to be proportionately higher in 1964 when exposure extends over a full 12-month period. The contribution to the GI dose from other sources was relatively insignificant. Conversely, the concentration of bone seekers, such as Sr^{90} and P^{32}, in the water was so low that drinking water did not significantly contribute to the bone dose.

The most appropriate "exposed population" to consider in relation to I^{131} intake and dose to the thyroid would appear to be small children of Pasco who drank water from the municipal system throughout the year (0.4 liters per day) as well as milk from the local stores (1 liter per day). Further, these same children were assumed to eat daily about 25 g of fresh vegetables obtained from local markets. The total intake of I^{131} for the year is estimated at about 2,000 pc or an average of about 5 pc per day. This is in the middle of the FRC Range I—the lowest range.

The estimated total body exposure from artificial radionuclides was about 15 mrems for the average Richland resident for 1963. Virtually all of this contribution is assigned to Sr^{90} from fallout and the method of calculation yields a value that is unrealistically high as mentioned in the case of the "Maximum Individual". The total dose does, however, include a small contribution (about 1 mrem) from nuclides of Hanford origin (principally Na^{24} and Zn^{65}) ingested with drinking water and (Zn^{65} only) beef and sea foods. This total body exposure may be compared with the FRC guide of 170 mrems for the average of suitable sample of an exposed population. Exposure from natural background sources in this region is estimated at about 150 mrems per year (excluded from the FRC guide).

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[4] Editor's Note: Federal Radiation Council Guidance based on a projected dose for children approximately one year of age, assumes 30 percent retention of ingested iodine in a 2 gram thyroid, and ingestion of 1 liter of milk daily (*5*). Thus the maximum thyroid dose postulated in this report is highly conservative.

CONCLUSIONS

Comprehensive environmental surveillance of the Hanford environs during 1963 showed that the amounts of radioactive materials present were well within nationally accepted limits at all times and, thus, that the releases of radioactive wastes were adequately controlled.

The most significant source of exposure from the Hanford plants continued to be the P^{32} released to the Columbia River in the reactor effluent and subsequently concentrated by local fish. Individuals who ate such fish as a major part of their diet throughout the year and who also ate large quantities of produce grown on farms irrigated with Columbia River water could conceivably have taken in as much as 50% of the annual permissible amount of bone-seeking radionuclides.

One unusual release of I^{131} occurred from one of the separations plants in September. Extensive surveillance at the time showed that the temporary increase in the I^{131} content of milk and other foods did not substantially alter the annual radiation dose to thyroids of people living in the vicinity of the plant. More Sr^{90} from world-wide fallout was noted in 1963 than in 1963 and consequently the exposure from this source was slightly higher.

Previous coverage in *Radiological Health Data*

Period	Issue
1959 and first and second quarters 1960	*May 1961*
Third and fourth quarters 1960 and first and second quarters 1961	*February 1962*
Third and fourth quarter 1961	*October 1962*
Calendar year 1962	*January 1964*

2. Oak Ridge Area, January–June 1964

Union Carbide Nuclear Company, Oak Ridge, Tennessee

Oak Ridge Area is a complex made up of many installations, including K–25, X–10, and Y–12 areas, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in Oak Ridge Area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ion exchange activity that enables it to fix radioactive materials. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air Monitoring

Atmospheric contamination by long-lived fission products and fallout occurring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of seven stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge Area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur. Sampling is carried out by passing air continuously through a filter paper. Average concentrations are presented in table 8.

TABLE 8.—LONG-LIVED GROSS BETA CONCENTRATIONS [1] IN AIR OAK RIDGE AREA

[Average concentrations in pc/m³]

Perimeter stations (see figure 1)	First half 1964	Remote stations (see figure 2)	Second half 1964
HP-31	1.3	HP-51	1.6
HP-32	1.5	HP-52	1.7
HP-33	1.1	HP-53	1.7
HP-34	1.2	HP-54	1.9
HP-35	1.4	HP-55	2.0
HP-36	1.4	HP-56	1.4
HP-37	1.3	HP-57	1.6
Average	1.3	Average	1.7

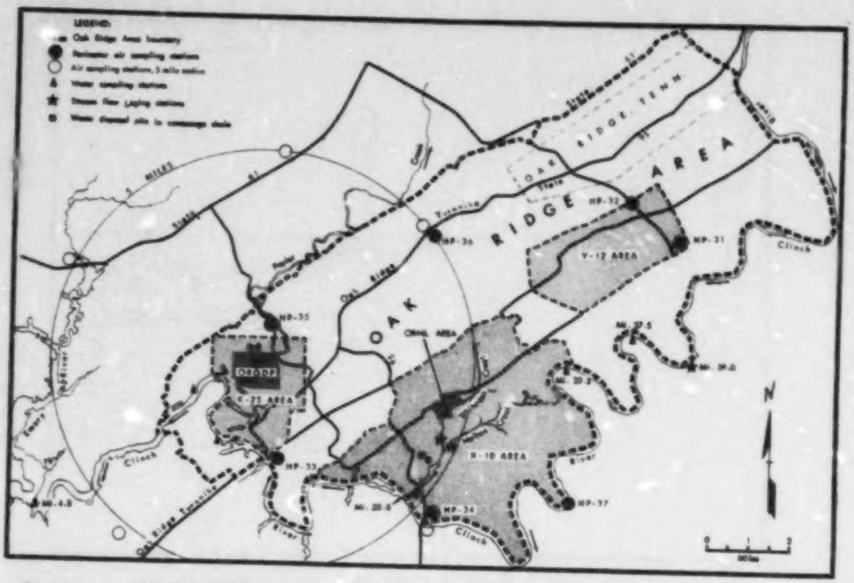
LEGEND:
Oak Ridge Area boundary
Perimeter air sampling stations
Air sampling stations, 5 mile radius
Water sampling stations
Stream flow gaging stations
5 MILES
OAK RIDGE AREA
OAK RIDGE, TENN.
Y-12 AREA
X-10 AREA
K-25 AREA
ORGDP
ORNL AREA
HP-31
HP-32
HP-33
HP-34
HP-35
HP-36
HP-37
Clinch
River
Oak Ridge Turnpike
N
Miles

Figure 1.—OAK RIDGE AREA ENVIRONMENTAL SAMPLING LOCATIONS

Atmospheric contamination by uranium is determined by gross alpha measurements of continuous 8-hour air samples taken at five locations on a five-mile radius from the ORGDP (figure 1). The data are summarized in table 9.

Table 9.—LONG-LIVED ALPHA ACTIVITY IN AIR [1] FIVE MILES FROM ORGDP

[Average concentrations in pc/m³]

Direction from plant	First half 1964
North	0.3
East	0.45
Southwest	0.40

[1] Interpreted as uranium (natural).

Water Monitoring

Large volume, low level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. The concentration of radioactivity leaving White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream gauging operations are carried on continuously by the U. S. Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, for uranium, and for the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system is such that no short-lived radionuclides are present. The averages are given in tables 10 and 11.

Gamma Measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above ground, and the results are shown in table 12 in terms of mr/hr.

76

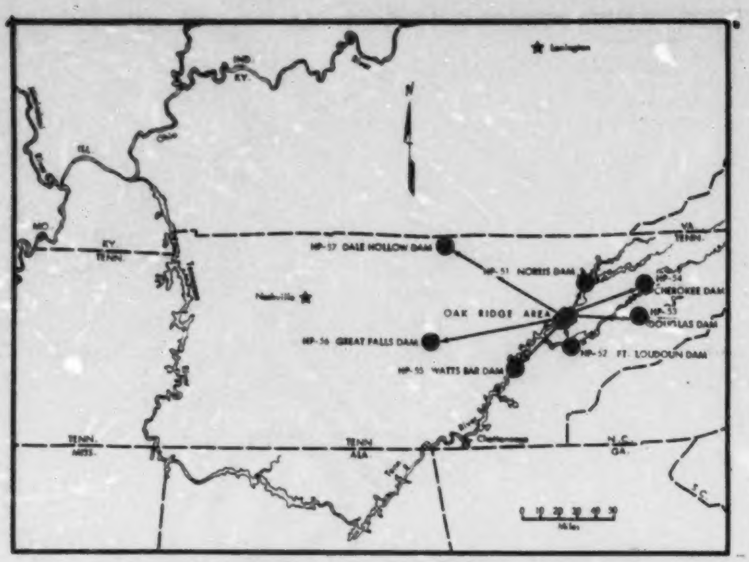
Lexington
IND.
KY.
OHIO
ILL.
MO.
KY.
TENN.
N
Nashville
HP-57 DALE HOLLOW DAM
HP-51 NORRIS DAM
HP-54
CHEROKEE DAM
OAK RIDGE AREA
HP-53
DOUGLAS DAM
HP-56 GREAT FALLS DAM
HP-52 FT. LOUDOUN DAM
HP-55 WATTS BAR DAM
VA.
TENN.
Chattanooga
TENN.
MISS.
TENN.
ALA.
N.C.
GA.
S.C.
0 10 20 30 40 50
Miles

FIGURE 2.—REMOTE AIR MONITORING STATIONS; OAK RIDGE AREA

TABLE 10.—CONCENTRATIONS OF MAJOR RADIONUCLIDES IN THE CLINCH RIVER

[Average concentrations in pc/liter]

Radionuclide	First half 1964		
	Location on Clinch River [a]		
	Mi. 41.5 (Upstream)	Mi. 20.8 [b] (Outfall)	Mi. 4.5 (Downstream)
Sr^{90}	1.4	2.9	3.6
Ce^{144}	1.2	0.1	1.3
Cs^{137}	0.6	2.7	4.3
Ru^{106}	4.1	84	77
Co^{60}	—	6.0	6.5
Zr^{95}-Nb^{95}	0.1	<0.1	0.5
Gross beta	7.2	240	93

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.

[b] The concentrations at mi. 20.8 are not measured directly but the values are calculated on the basis of levels of waste released and the dilution afforded by the river.

TABLE 11.—URANIUM CONCENTRATIONS IN THE CLINCH RIVER, OAK RIDGE AREA

[Average concentrations in pc/liter]

Sampling location	First half 196[illegible]	
	No. of samples	Uranium concentration
Upstream from ORGDP	24	1
Downstream from ORGDP	24	1

TABLE 12.—EXTERNAL GAMMA RADIATION LEVELS, OAK RIDGE AREA

[Average dose rates in mr/hr]

Location	First half 1964
Solway Gate	0.015
Y-12 East Portal	0.012
Newcomb Road	0.014
Gallaher Gate	0.016
White Wing Gate	0.013
Average	0.014

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*September 1962*
1962	*September 1963*
1963	*July 1964*

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REPORTED NUCLEAR DETONATIONS, DECEMBER 1964

Four United States nuclear tests were announced by the Atomic Energy Commission during December 1964. The first, an underground test of low-intermediate yield (20–200 kilotons), took place at the Nevada Test Site on December 5. On December 16 two low-yield underground tests were conducted at the Site. (Low yield is defined as less than 20 kilotons of TNT.)

The December 18 test was another in the series of Plowshare experiments for peaceful uses of nuclear explosives. This 1/10 kiloton yield test was conducted at a depth of 90 feet.

These tests have been assigned the arbitrary *RHD* reference numbers 173 through 176 in order of their occurrence.

RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis for alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also compared in beta concentration isograms.

1. Radiation Surveillance Network, October 1965

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which regularly gathers samples from 73 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting Function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators telephone any daily field estimates over 10 pc/m^3 to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Lower field estimates are reported to the Center by the laboratory at Rockville, Maryland, which receives a daily written report together with the air filter submitted by each station operator. The filters are counted at the laboratory to confirm field estimates. Analyses for specific radionuclides may also be made if gross beta activity concentrations are high. All field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air Sampling Procedure and Results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90}

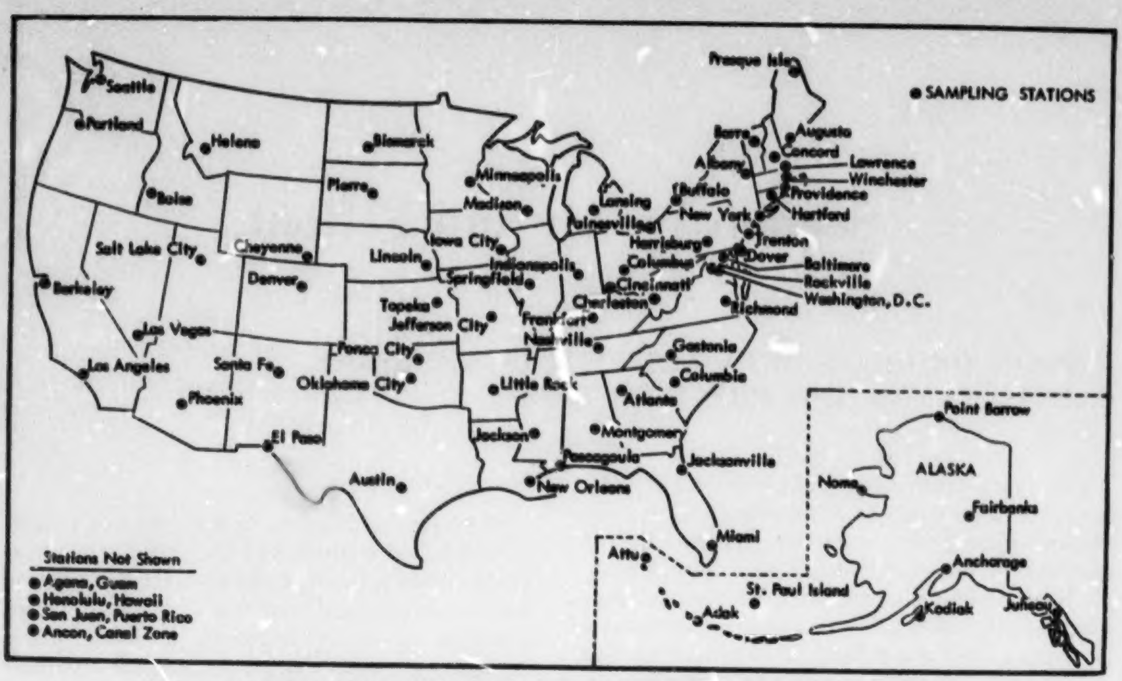
SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Buffalo
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Providence
Hartford
New York
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Painesville
Harrisburg
Columbus
Cincinnati
Charleston
Richmond
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Berkeley
Denver
Topeka
Jefferson City
Frankfort
Nashville
Las Vegas
Ponca City
Gastonia
Columbia
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Atlanta
Phoenix
El Paso
Jackson
Montgomery
Pascagoula
Jacksonville
Austin
New Orleans
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

standard. Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*).

Times profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

Precipitation Measurements

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inch of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D=\frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C}=\frac{\Sigma D}{\Sigma P}\times 1000$$

The October 1964 average concentrations and total depositions are given in table 1.

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[1] If [illegible] sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently, the calculated age will be overestimated.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, OCTOBER 1964

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Total Depth (mm)[b]	Total deposition (nc/m²)[b]
			Maximum	Minimum	Average[a]			
Ala:	Montgomery	26	8.61	<0.10	1.29	Aug 64	162.4	32.6
Alaska:	Adak	25	0.52	<0.10	<0.19	Nov 64		
	Anchorage	31	0.69	<0.10	<0.19	Jul 64	43.2	9.0
	Attu	31	0.51	<0.10	<0.16	Dec 64		
	Fairbanks	27	2.82	<0.10	<0.24	Aug 64	17.0	35.3
	Juneau	12	1.06	<0.10	<0.21	Sep 64	26.3	40.5
	Kodiak	27	1.01	<0.10	<0.14	Oct 64		
	Nome	24	0.33	<0.10	<0.12	Feb 64		
	Point Barrow	17	5.69	<0.10	0.81	Jan 65		
	St. Paul Island	29	0.36	<0.10	<0.13	Mar 64		
Ariz:	Phoenix	21	1.69	0.18	0.66	Sep 64		
Ark:	Little Rock	26	2.82	0.16	0.77	Sep 64	7.6	1.5
Calif:	Berkeley	31	0.87	<0.10	0.25	Oct 64	34.6	15.7
	Los Angeles	31	0.75	<0.10	0.25	Feb 64	8.9	2.8
Canal Zone:	Ancon	18	0.26	<0.10	<0.10	Nov 64		
Colo:	Denver	29	20.07	0.16	2.68	Oct 64	5.2	1.0
Conn:	Hartford	30	5.45	0.13	0.72	Oct 64	44.3	11.1
Del:	Dover	21	7.59	<0.10	0.96	Aug 64		
D. C:	Washington	31	9.01	<0.10	1.04	Apr 64	34.6	9.0
Fla:	Jacksonville	29	9.65	<0.10	1.50	Sep 64	109.6	39.2
	Miami	28	15.90	<0.10	2.87	Oct 64	203.8	84.3
Ga:	Atlanta					Jul 64	147.5	20.5
Guam:	Agana	31	1.14	<0.10	<0.17	Apr 64		
Hawaii:	Honolulu	31	8.70	<0.10	1.14	Feb 64	29.4	17.7
Idaho:	Boise	26	10.71	0.24	1.63	Dec 64	8.7	3.5
Ill:	Springfield	31	2.87	0.13	0.60	Mar 64		
Ind:	Indianapolis	24	2.00	<0.10	0.53	Jul 64	13.6	3.6
Iowa:	Iowa City	31	1.06	<0.10	0.39	Nov 64		
Kans:	Topeka	25	1.94	<0.10	0.35	Jul 64	5.0	2.7
Ky:	Frankfort	31	4.80	<0.10	0.77	Feb 64	15.1	10.6
La:	New Orleans	29	6.07	<0.10	0.85	Mar 64	72.9	42.6
Maine:	Augusta	30	5.21	<0.10	0.82	Mar 64	89.6	35.6
	Presque Isle	22	3.63	<0.10	0.45	Nov 64	17.0	23.9
Md:	Baltimore	26	6.49	<0.10	0.75	Oct 64	19.9	4.0
	Rockville	19	9.63	<0.10	0.86	Mar 64		
Mass:	Lawrence	31	7.25	<0.10	0.87	Aug 64	38.7	17.5
	Winchester	29	4.45	<0.10	0.73	Apr 64	52.5	15.6
Mich:	Lansing	31	2.78	0.14	0.72	Feb 64	10.2	15.5
Minn:	Minneapolis	26	1.40	<0.10	0.27	Mar 64	12.1	5.1
Miss:	Jackson	27	5.81	<0.10	1.26	Apr 64	96.9	37.7
	Pascagoula	21	15.68	<0.10	1.42	Dec 64		
Mo:	Jefferson City	27	1.05	0.11	0.36	Jul 64	5.3	2.8
Mont:	Helena	31	28.90	<0.10	2.46	Nov 64	0.63	0.70
Nebr:	Lincoln	17	4.10	<0.10	<0.43	Apr 64		
Nev:	Las Vegas	30	24.62	<0.10	2.00	Aug 64		
N. H:	Concord	18	6.26	<0.10	0.88	Feb 64		
N. J:	Trenton	30	7.21	<0.10	0.76	Mar 64	10.4	2.0
N. Mex:	Santa Fe	27	10.49	0.21	1.56	Nov 64		
N. Y:	Albany	25	8.47	<0.10	0.84	Jul 64	13.5	3.1
	Buffalo	19	4.21	0.18	0.70	Nov 64		
	New York	31	7.84	<0.10	0.91	Dec 64		
N. C:	Gastonia	28	6.55	<0.10	0.95	Nov 64	158.6	33.0
N. Dak:	Bismarck	30	13.96	<0.10	1.02	Feb 64	2.6	4.7
Ohio:	Cincinnati	23	3.89	0.16	0.88	Aug 64		
	Columbus	30	4.57	<0.10	0.69	Apr 64	10.2	9.5
	Painesville	30	5.02	<0.10	0.89	Oct 64	60.2	34.5
Okla:	Oklahoma City	30	2.79	<0.10	0.53	Apr 64		
	Ponca City	29	0.82	<0.10	0.27	Oct 64	50.2	30.7
Ore:	Portland	30	8.21	0.11	0.95	Oct 63	35.2	8.2
Pa:	Harrisburg	29	8.07	<0.10	0.77	Jul 64	12.3	2.5
P. R:	San Juan	31	0.37	<0.10	<0.14	Mar 64	23.6	4.5
R. I:	Providence	31	3.85	<0.10	0.56	Jan 64	62.3	12.5
S. C:	Columbia	27	7.41	<0.10	0.71	Dec 64	310.5	62.2
S. Dak:	Pierre	31	17.07	<0.10	1.18	Sep 64		
Tenn:	Nashville	31	2.77	0.13	0.73	Jan 64	37.1	21.7
Tex:	Austin	30	3.62	<0.10	0.52	Aug 64	52.5	10.5
	El Paso	31	6.38	0.12	0.80	Jan 64	6.7	1.4
Utah:	Salt Lake City	29	22.50	<0.10	2.57	Aug 63	15.9	4.7
Vt:	Barre	29	6.31	0.12	0.91	Sep 64	43.7	27.7
Va:	Richmond	31	7.04	<0.10	0.99	Sep 64	60.0	14.3
Wash:	Seattle	30	1.03	<0.10	0.21	Jul 64	17.[illegible]	3.6
	Spokane	30	10.87	<0.10	0.66	New		
W. Va:	Charleston	31	6.27	0.12	0.82	Dec 64	9.1	6.0
Wis:	Madison	30	1.55	<0.10	0.53	Sep 64	3.5	3.6
Wyo:	Cheyenne	31	12.84	0.12	1.80	Aug 64		
Network summary[d]		2,032	28.9	<0.10	0.82		46.9	17.1

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign appears before the average.

[b] Blank indicates no report received.

[c] Station added to network September 1964.

[d] For the network summary, all averages are the arithmetic average of the station averages.

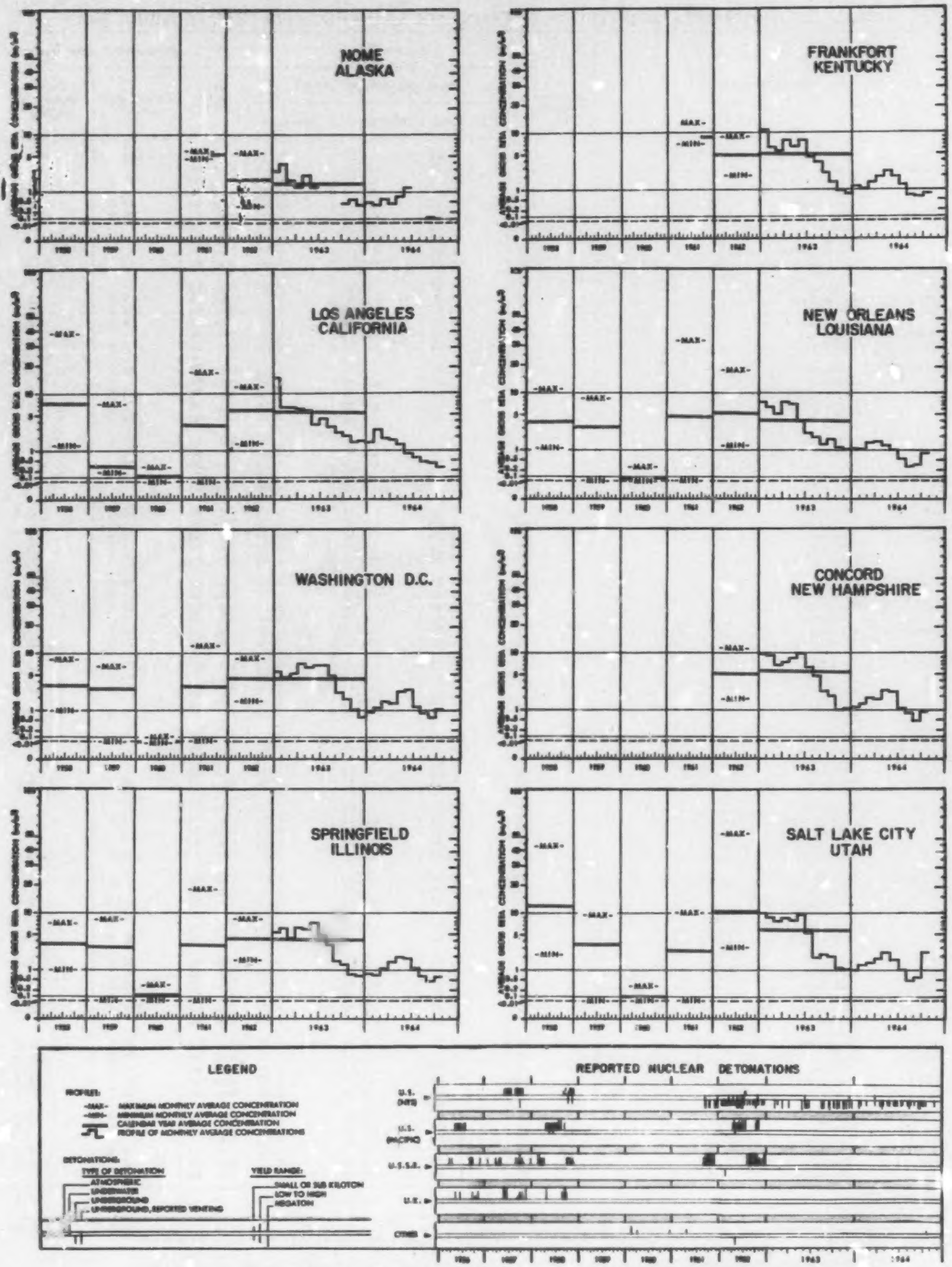

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–OCTOBER 1964

Significant increases over the previous month in both the maximum and average air concentrations are observed in the data presented. These increases are presumably the result of nuclear testing conducted by Mainland China on October 16, 1964. More detailed discussions concerning the detection of nuclear debris from Chinese tests are presently being prepared.

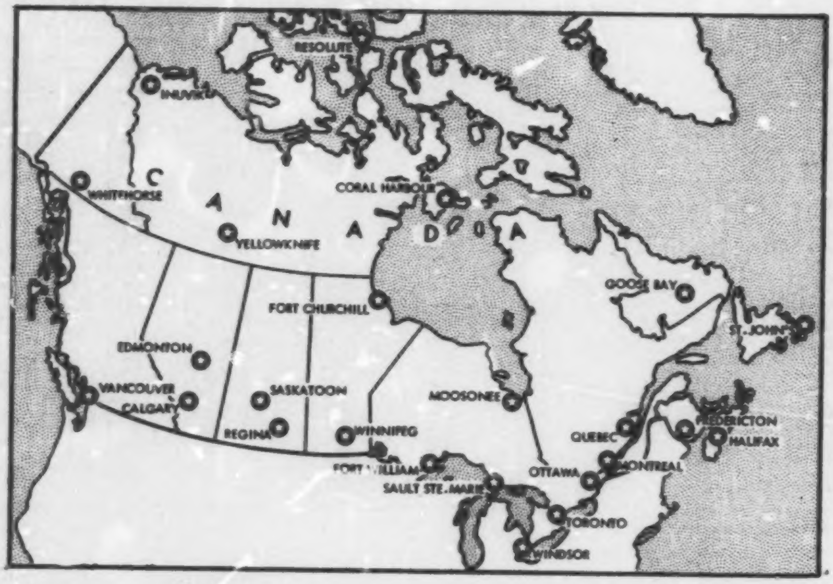
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

2. Canadian Air Monitoring Program[2]
October 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for October 1964 are given in table 2 and presented in conjunction with U.S. and Mexican data by an isogram map (figure 5).

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[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Programs*, Vol. 2, No. 11: 11–24 (November 1964), Canadian Department of National Health and Welfare, Ottawa, Canada.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, OCTOBER 1964

Station location	Air surveillance				Precipitation Measurements	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	30	49.2	0.1	3.7	890	16.1
Coral Harbour	30	0.4	0.1	0.2	128	1.9
Edmonton	29	5.7	0.1	2.1	3,466	22.0
Ft. Churchill	14	1.5	0.1	0.3	358	4.0
Ft. William	31	6.6	0.1	0.9	853	24.7
Fredericton	31	3.9	0.1	0.5	230	15.2
Goose Bay	31	0.8	0.1	0.2	89	9.8
Halifax	29	1.2	0.1	0.3	165	20.0
Inuvik	31	4.8	0.0	0.6	361	12.6
Montreal	31	3.5	0.1	0.6	338	14.8
Moosonee	31	7.2	0.1	0.8	240	13.4
Ottawa	31	3.1	0.0	0.4	330	10.2
Quebec	31	5.5	0.1	0.7	709	42.1
Regina	31	5.0	0.1	1.5	**	3.6
Resolute	30	0.3	0.1	0.2	254	11.6
St. John's, Nfld	31	0.9	0.1	0.3	91	19.2
Saskatoon	31	11.2	0.1	1.3	1,673	17.8
Sault Ste. Marie	30	1.4	0.1	0.5	167	10.7
Toronto	31	1.8	0.1	0.5	1,166	45.3
Vancouver	31	4.6	0.1	0.4	272	11.6
Whitehorse	31	4.3	0.1	0.5	456	7.1
Windsor	29	3.9	0.1	0.7	1,219	24.4
Winnipeg	31	7.0	0.1	0.8	4,182	24.4
Yellowknife	30	6.1	0.0	0.4	171	4.4
Network summary		6.7	0.1	0.8	774	16.1

** Trace precipitation.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for October 1964 samples are given in table 2. Radionuclide analyses are reported quarterly in *RHD*.

3. Mexican Air Monitoring Program October 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión

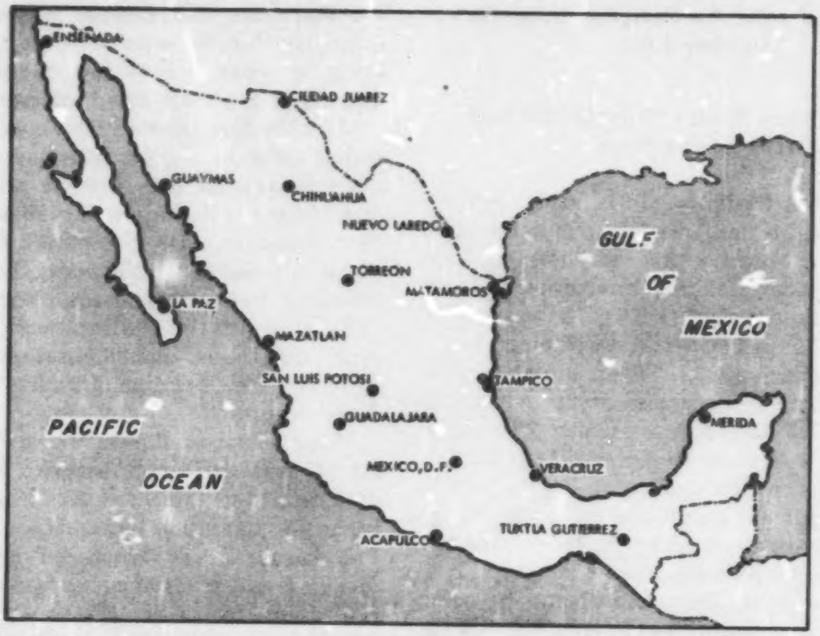
ENSENADA
CIUDAD JUAREZ
GUAYMAS
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
LA PAZ
MAZATLAN
GULF OF MEXICO
SAN LUIS POTOSI
TAMPICO
GUADALAJARA
MERIDA
PACIFIC OCEAN
MEXICO, D.F.
VERACRUZ
TUXTLA GUTIERREZ
ACAPULCO

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24 hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during October 1964 are presented in table 3. The data are also represented in the beta activity isogram map of North America, figure 5.

TABLE 3.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO 1964

Station	Number of Samples	Gross beta activity (pc/m^3)		
		Maximum	Minimum	Average
Acapulco	12	0.4	<0.1	0.1
Ciudad Juárez	15	3.4	<0.1	0.5
Chihuahua	18	0.3	<0.1	0.2
Ensenada	10	0.3	<0.1	0.2
Guadalajara	8	0.3	<0.1	0.1
Guaymas	20	0.4	<0.1	0.2
La Paz	17	0.2	<0.1	0.1
Matamoros	8	0.4	<0.1	0.3
Mazatlán	28	0.5	<0.1	0.1
Mérida	14	3.9	<0.1	1.4
México, D.F.	17	0.7	<0.1	0.2
Nuevo Laredo	12	2.6	0.2	0.7
San Luis Potosí	20	5.9	<0.1	0.7
Tampico	22	1.3	0.1	0.3
Torreón	25	2.8	<0.1	0.5
Tuxtla Gutiérres [a]				
Veracruz	24	3.2	<0.1	0.6

[a] Blank indicates station temporarily shut down.

4. Pan American Air Sampling Program October 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

The October 1964 air monitoring data from the four participating countries are given in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN AIR, OCTOBER 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	14	0.21	<0.10	<0.11
Caracas, Venezuela	21	0.15	<0.10	<0.10
Lima, Peru	19	0.25	<0.10	<0.13
Santiago, Chile	30	0.37	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

5. Gross Beta Activity in Air, North America October 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*13*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*14*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

Figure 5 shows the October 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network, the Pan American Air Sampling Program, and the Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN and Pan American data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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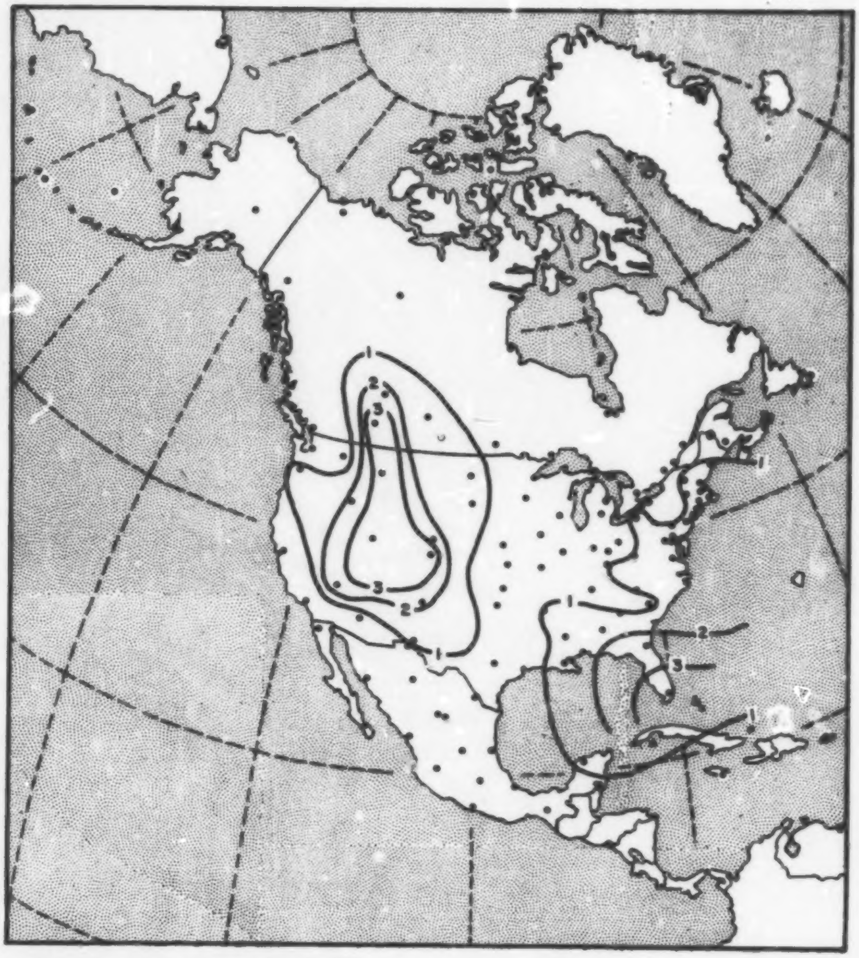

FIGURE 5.—ISOGRAM OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR, NORTH AMERICA, OCTOBER 1964

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, October 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

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Sampling Procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL), for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after monthly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

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Analytical Procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	±5	50 or greater	±10
Strontium-90	0 to 20	±2	20 or greater	±10

[a] Two standard deviations (2σ).

The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for the month of October 1964 (actual reporting period September 27–October 31, 1964). Although not shown in table 2, barium–140 monthly average concentrations in milk were less than 10 pc/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations *versus* radionuclide concentrations in milk, tables 3 and 4 have been prepared from the monthly averages shown in table 2.

The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3.

Each graph shows the strontium–90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, OCTOBER 1964

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (gm/liter)		Strontium-89 (pc/liter)		Strontium-90 (pc/liter)		Cesium-137 (pc/liter)		Iodine-131 (pc/liter)		Barium-140 (pc/liter)	
		Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month
Ala:	Montgomery	1.17	1.15	<5	<5	21	18	65	60	0	0	0	0
Alaska:	Palmer	1.17	1.20	<5	<5	16	19	105	85	0	0	0	0
Ariz:	Phoenix	1.15	1.19	<5	<5	3	5	25	20	0	0	0	0
Ark:	Little Rock	1.15	1.16	<5	5	38	34	80	65	0	0	0	0
Calif:	Sacramento	1.26	1.20	<5	<5	6	6	30	20	0	0	0	0
	San Francisco	1.22	1.20	<5	<5	7	11	35	20	0	0	0	0
C. Z:	Cristobal	1.11	1.12	<5	<5	5	5	50	55	0	0	0	0
Colo:	Denver	1.25	1.26	<5	<5	20	17	100	75	0	0	0	0
Conn:	Hartford	1.10	1.11	<5	<5	19	14	110	75	0	0	0	0
Del:	Wilmington	1.15	1.17	<5	<5	20	14	85	65	0	0	0	0
D. C:	Washington	1.11	1.12	<5	<5	19	18	65	50	0	0	0	0
Fla:	Tampa	1.19	1.16	<5	<5	17	16	[illegible]	225	0	0	0	0
Ga:	Atlanta	1.17	1.18	<5	5	28	24	105	90	0	0	0	0
Hawaii:	Honolulu	1.19	1.21	<5	10	11	15	70	70	0	0	0	0
Idaho:	Idaho Falls	1.24	1.22	<5	<5	25	14	110	60	0	0	0	0
Ill:	Chicago	1.14	1.15	<5	<5	19	15	85	70	0	0	0	0
Ind:	Indianapolis	1.15	1.18	<5	<5	18	14	70	55	0	0	0	0
Iowa:	Des Moines	1.21	1.23	<5	<5	22	19	70	45	0	0	0	0
Kans:	Wichita	1.17	1.24	<5	<5	18	16	50	45	0	0	0	0
Ky:	Louisville	1.13	1.15	<5	<5	27	22	50	45	0	0	0	0
La:	New Orleans	1.19	1.21	<5	<5	48	39	115	90	0	0	0	0
Maine:	Portland	1.14	1.15	<5	<5	29	22	175	135	0	0	0	0
Md:	Baltimore	1.13	1.13	<5	<5	21	18	70	50	0	0	0	0
Mass:	Boston	1.13	1.15	<5	<5	31	21	180	105	0	0	0	0
Mich:	Detroit	1.14	1.16	<5	<5	16	16	90	70	0	10	0	0
	Grand Rapids	1.15	1.21	<5	<5	19	18	100	85	0	0	0	0
Minn:	Minneapolis	1.21	1.25	<5	10	27	24	115	70	0	0	0	0
Miss:	Jackson	1.21	1.19	<5	<5	37	33	85	65	0	0	0	0
Mo:	Kansas City	1.19	1.21	<5	<5	26	21	55	35	0	0	0	0
	St. Louis	1.20	1.24	<5	<5	21	17	55	45	0	0	0	0
Mont:	Helena	1.20	1.2[illegible]	<5	<5	20	15	115	85	0	10	0	0
Nebr:	Omaha	1.21	1.23	<5	<5	24	19	70	45	0	0	0	0
Nev:	Las Vegas	1.19	1.18	<5	<5	6	7	50	35	0	10	0	0
N. H:	Manchester	1.17	1.20	<5	<5	30	23	205	140	0	0	0	0
N. J:	Trenton	1.12	1.12	<5	<5	18	14	85	65	0	0	0	0
N. Mex:	Albuquerque	1.19	1.22	<5	<5	9	9	45	35	0	10	0	0
N. Y:	Buffalo	1.09	1.09	<5	<5	18	14	105	80	0	0	0	0
	New York	1.09	1.14	<5	<5	25	18	120	85	0	0	0	0
	Syracuse	1.12	1.11	<5	<5	15	15	80	80	0	0	0	0
N. C:	Charlotte	1.17	1.19	<5	<5	38	34	100	70	0	0	0	0
N. Dak:	Minot	1.22	1.18	10	<5	49	39	145	100	0	0	0	0
Ohio:	Cincinnati	1.17	1.21	<5	<5	19	16	60	50	[illegible]	0	0	0
	Cleveland	1.12	1.21	<5	<5	19	17	90	65	[illegible]	0	0	0
Okla:	Oklahoma City	1.12	1.12	<5	<5	19	17	50	45	0	0	0	0
Ore:	Portland	1.24	1.29	<5	<5	30	22	165	85	0	0	0	0
Pa:	Philadelphia	1.11	1.19	<5	<5	18	15	80	70	0	0	0	0
	Pittsburgh	1.14	1.20	<5	<5	29	21	120	80	0	0	0	0
P. R:	San Juan	1.15	1.12	<5	<5	12	11	70	55	0	0	0	0
R. I:	Providence	1.13	1.18	<5	<5	23	19	140	95	0	0	0	0
S. C:	Charleston	1.15	1.14	<5	<5	31	31	110	95	0	0	0	0
S. Dak:	Rapid City	1.19	0.98	<5	<5	43	28	125	100	0	0	0	0
Tenn:	Chattanooga	1.20	1.18	<5	<5	39	33	90	65	0	0	0	0
	Memphis	1.16	1.16	<5	<5	28	27	55	40	0	0	0	0
Tex:	Austin	1.11	1.12	<5	<5	7	7	35	20	0	0	0	0
	Dallas	1.14	1.15	<5	<5	17	14	45	30	0	0	0	0
Utah:	Salt Lake City	1.27	1.41	<5	<5	25	18	165	90	0	0	0	0
Vt:	Burlington	1.13	1.16	<5	<5	25	19	140	90	0	10	0	0
Va:	Norfolk	1.13	1.17	<5	5	23	23	75	65	0	0	0	0
Wash:	Seattle	1.23	1.22	5	<5	28	16	170	105	0	0	0	0
	Spokane	1.22	1.28	<5	<5	26	23	130	85	0	0	0	0
W. Va:	Charleston	1.13	1.12	<5	<5	24	19	50	40	0	0	0	0
Wis:	Milwaukee	1.19	1.23	<5	<5	14	14	95	80	0	0	0	0
Wyo:	Laramie	1.18	1.22	<5	<5	20	14	105	60	0	0	0	0
Network average		1.17	1.18	<5	<5	22.3	18.7	94	69	0	<10	0	0

strontium–90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentrations in milk was given for March 1960–March 1964 in the July 1964 issue of *RHD* (*2*).

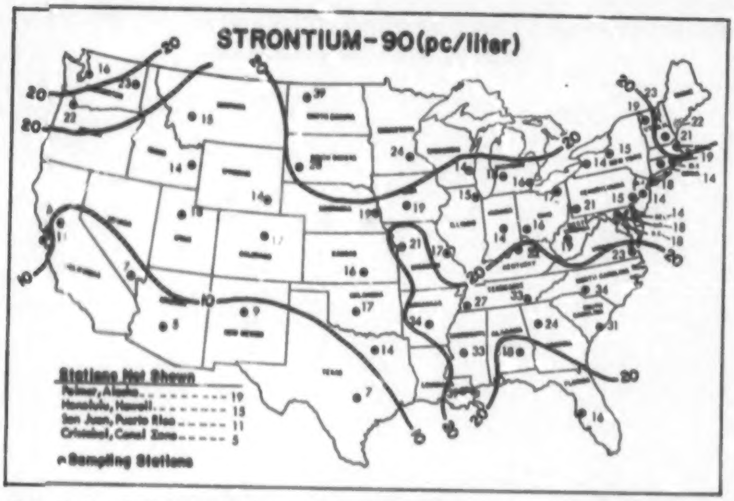
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 19
Honolulu, Hawaii 15
San Juan, Puerto Rico 11
Cristobal, Canal Zone 5
Sampling Stations

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, OCTOBER 1964

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES, FOR STRONTIUM-90, MAY–OCTOBER 1964

Range (pc/liter)	Number of stations in range, 1964					
	May	June	July	Aug.	Sept.	Oct.
Under 10	3	4	6	7	8	6
10–19	8	6	6	23	27	37
20–29	20	23	29	23	20	13
30–39	20	17	14	6	6	7
40–49	6	10	4	4	2	0
50–59	4	2	1	0	0	0
60–69	1	0	2	0	0	0
70–79	1	1	0	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, MAY–OCTOBER 1964

Range (pc/liter)	Number of stations in range, 1964					
	May	June	July	Aug.	Sept.	Oct.
Under 50	2	1	4	6	14	16
50–99	16	19	24	30	33	40
100–149	17	24	21	19	13	6
150–199	23	13	8	6	2	0
200–249	3	4	3	1	1	1
250–299	2	2	2	1	0	0

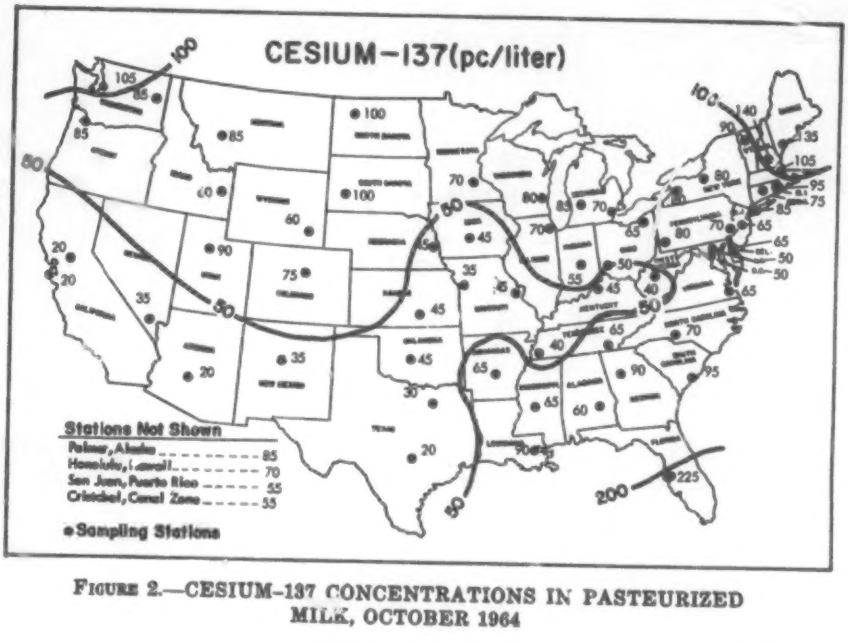
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 85
Honolulu, Hawaii 70
San Juan, Puerto Rico 55
Cristobal, Canal Zone 55
Sampling Stations

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, OCTOBER 1964

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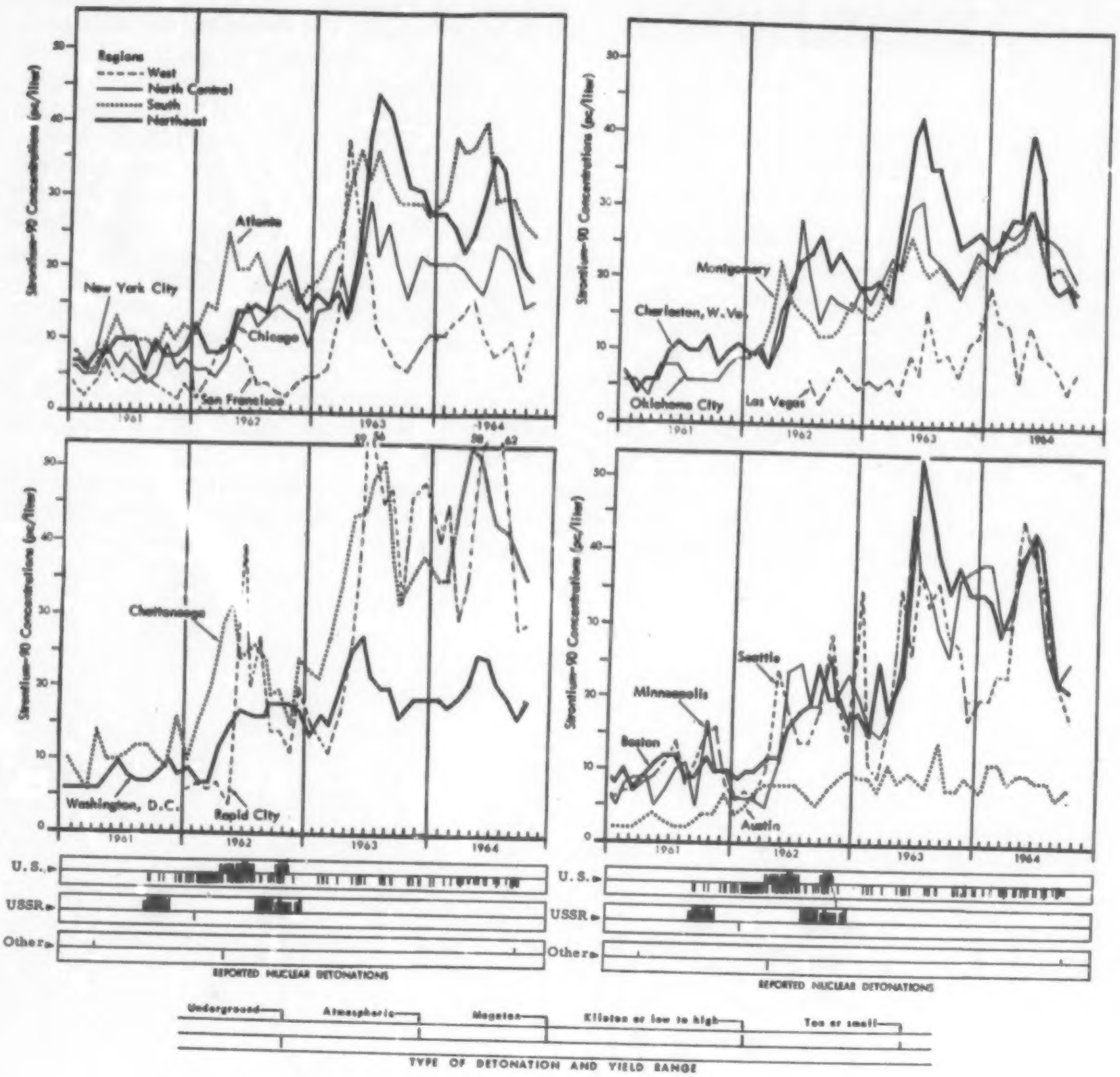

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–OCTOBER 1964

Correction for January 1965 Issue

In figure 2 on page 19 in the January 1965 issue of *Radiological Health Data*, the contour line extending from Oregon through West Virginia and on to Texas is labeled "200". Subsequent inspection of the data shows that the line should have been labeled "50".

2. Colorado Milk Network, July–September 1964

Occupational and Radiological Health Division, Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. The Denver Health Department collects weekly pasteurized milk composited samples from all major producers in the Denver area.

The State is divided into three major milk producing areas: west, northeast, and southeast. Routine sampling of raw milk began in August 1962. Raw milk shipped into Colorado from eastern Utah was also sampled. The four source areas are shown in figure 4. The frequency of sampling varies one to seventeen times per month in each active sampling area.

Samples are analyzed with the Division's low level counting facilities. The shield is an eight-food cube having five-inch steel walls lined with one-eighth inch of lead on the inside. A two-quart milk sample in a stainless steel container is analyzed with a 3 x 5-inch thallium-activated sodium iodide crystal and a 512-channel pulse height analyzer for forty minutes. The system is calibrated for routine calculation by the matrix method for the radionuclides iodine–131, barium–140, cesium–137, and potassium–40. The minimum detectable amount for the first three radionuclides at the 95 percent confidence level (± two standard deviations) is 20 pc/liter.

Table 5 gives the radionuclide concentration in milk samples collected from July through September 1964.

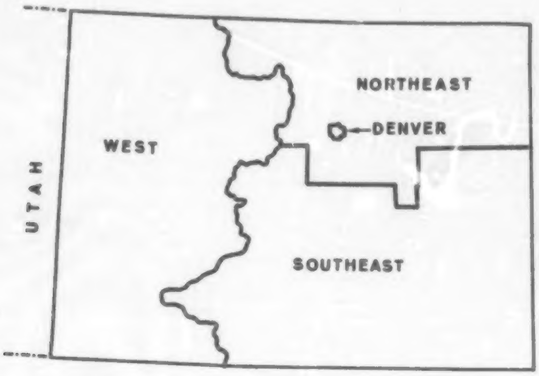

FIGURE 4.—COLORADO MILK SAMPLING AREAS

TABLE 5.—RADIONUCLIDES AND STABLE POTASSIUM IN COLORADO MILK, JULY-SEPTEMBER 1964[a]

[Radionuclide concentrations in pc/liter, potassium concentrations in g/liter]

Date (1964)	Raw milk												Pasteurized milk		
	Northeast			Southeast			West			Eastern Utah			Denver		
	K	I^{131}	Cs^{137}	K	I^{131}	Cs^{137}	K	I^{131}	Cs^{137}	K	I^{131}	Cs^{137}	K	I^{131}	Cs^{137}
July	1.45	<20	115	1.50	<20	75	[b] —	—	—	—	—	—	1.53	<20	123
August	1.44	<20	85	1.27	<20	68	1.15	<20	78	1.36	<20	121	1.54	<20	100
September	1.49	<20	76	1.51	<20	57	1.26	<60	20	1.32	<20	104	1.46	<20	77

[a] Barium-140 monthly averages were <20 pc/liter.
[b] Dash indicates no analysis.

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3. Pennsylvania Milk Network, August–September 1964

Bureau of Environmental Health, Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 5). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium-90 analyses have been carried out since April 1963.

The chemical separation technique for strontium-90 is essentially an ion exchange method described by Porter, *et al* (*3*). One liter of milk is passed through an ion exchange column; yttrium-90 is eluted from the resin and is counted in an automatic low background proportional counter.

The monthly average strontium-90 levels in pasteurized milk are shown in table 6.

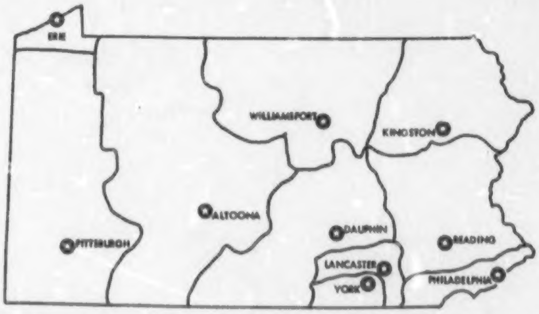

FIGURE 5.—PENNSYLVANIA MILK SAMPLING STATIONS AND MILK CONSUMPTION AREAS

TABLE 6. STRONTIUM-90 IN PENNSYLVANIA MILK, AUGUST–SEPTEMBER 1964

[Concentrations in pc/liter]

Sampling location	August	September
Altoona	35	30
Dauphin	25	21
Erie	28	25
Kingston	38	32
Lancaster	26	22
Philadelphia	28	24
Pittsburgh	31	30
Reading	20	19
Williamsport	34	27
York	20	20
State Average	28.5	25.0

Previous Coverage in *RHD* (Issue):

March 1964
July 1964
October 1964

4. Washington Milk Network[3] January–June 1964

Air Sanitation and Radiation Control Section State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 6, were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. As this sampling program also provides representation of a large percentage of the population's milk supply in the State, it would provide a basis for initiated countermeasures. In addition to sampling milk from eight locations in Washington, milk from Northwest Idaho (Sandpoint) is included in the network as this area forms a part of the Spokane milkshed. Several additional points are sampled from time to time.

Raw milk samples are collected routinely approximately every two weeks from individual tankers but the sampling frequency is flexible. Increased sampling can be initiated immediately if the need should arise.

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[3] Data from *Environmental Radiation Surveillance in Washington State*, Third Annual Report, August 1964.

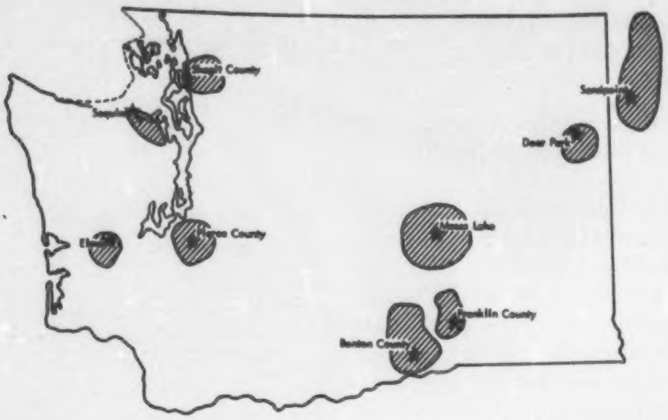

FIGURE 6.—WASHINGTON MILK SAMPLING LOCATIONS

Analytical Procedures

All milk samples are gamma scanned for 100 minutes in a 2-liter stainless steel Marinelli beaker. This beaker, which is placed in a 3″ x 3″ NaI (Tl) crystal, provides equal sample thickness on all sides and top of the crystal. The spectra are recorded with a 512-channel analyzer. A 4 x 4 matrix is used to analyze the spectra and provide rapid quantitative results for iodine–131, barium–140, cesium–137, and potassium–40.

An 800-minute background count is taken once each week. In order to check the stability of the analyzer, a one-minute count each day of a cesium–137 standard (solid) is done as an efficiency check, and a ten-minute count each week of the same source is done as a check on resolution. These counts must fall within two standard deviations of the average for the analyzer to be considered to be working normally. Gamma efficiencies, detectability limits and other characteristics of this system may be found in the "Washington Milk Network" article in the May 1964 issue of *RHD*.

Following gamma scanning, selected samples are analyzed for strontium–90. After the addition of strontium carrier, the milk proteins are precipitated with trichloracetic acid. Oxalic acid is then added to the sample to precipitate the alkaline earths as oxalates (pH 3.0). The oxalates are ashed, dissolved in 6 *N* hydrochloric acid, and the pH is adjusted to 1.4 to dissolve the ash. A double extraction using an equal volume of 20 percent di-(2–ethylhexyl) phosphoric acid (HDEHP) in toluene is performed. This effectively removes rare-earth activity, including yttrium–90, leaving the strontium–90 in the sample. This sample is stored a minimum of two weeks to allow yttrium–90 to ingrow. Subsequently, the yttrium–90 is extracted with 5 percent HDEHP in toluene solution. The organic layer is scrubbed with an HC1 solution (pH 1.4) and back extracted with 3N HNO_3. The resulting nitric acid solution is evaporated and yttrium–90 counted from which the strontium–90 activity is calculated. The yttrium–90 counting is done in a low-background, gas flow, internal proportional counter.

As a part of the laboratory's quality control program some samples are split and analyzed several times. Split samples are also exchanged with State, Federal and university laboratories for analyses and comparisons.

Results

Table 7 presents the monthly average radio nuclide content of raw milk for nine of the production areas in the major milksheds during the first six months of 1964. Iodine–131 and barium–140 have in general been nondetectable. For both cesium–137 and strontium–90 the Sandpoint production area had somewhat higher concentrations than the other areas during the period reported. Benton, Franklin, and Moses Lake have usually had the lower monthly averages.

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TABLE 7.—RADIONUCLIDE CONCENTRATIONS IN WASHINGTON MILK, JANUARY-JUNE 1964 [a]

[Concentrations in pc/liter]

Location	Potassium-40						Strontium-90						Cesium-137					
	Jan	Feb	Mar	Apr	May	June	Jan	Feb	Mar	Apr	May	June	Jan	Feb	Mar	Apr	May	June
Benton Co.	1092	1269	—	1089	—	1236	14	13	—	[c]	—	[c]	70	88	—	122	—	96
Deer Park	[b] —	1236	1122	1184	1135	—	—	26	25	[c]	32	—	—	169	163	157	177	—
Elma	1225	1186	1197	—	—	1173	21	[c]	13	—	—	46	133	100	93	—	—	314
Franklin Co.	—	1217	1085	1156	1217	—	—	[c]	13	11	15	—	—	81	82	71	79	—
Moses Lake		1270	1192	1144	1207	—	—	[c]	10	16	13	—	—	110	93	92	77	—
Pierce Co.	1327	—	1215	1109	1227	1063	19	—	[c]	18	48	[c]	129	—	107	150	321	174
Sandpoint, Idaho	—	1277	1187	1167	1190	—	—	47	43	48	[c]	—	—	325	328	327	283	—
Sequim	1288	1290	1107	1297	1155	1180	19	17	[c]	18	[c]	23	140	122	188	122	97	232
Skagit Co.	1176	1196	1138	1095	1116	1023	24	[c]	16	[c]	29	48	121	113	113	119	158	211

[a] All I^{131} and Ba^{140} monthly averages during this period were <10 and <15 pc/liter respectively.

[b] Dash indicates no sample.

[c] No analysis.

5. Canadian Milk Network,[4] October 1964

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 7) in the same areas as the air and precipitation stations. At present the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (4). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450 degrees C., dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is

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[4] Data from *Radiation Protection Programs*, Vol. 2, No. 11: 25-30, Radiation Protection Division, Canadian Department of National Health and Welfare (Nov. 1964).

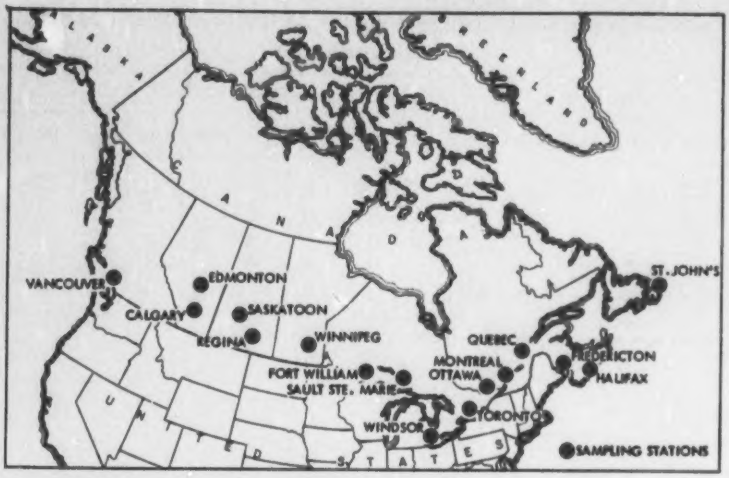

FIGURE 7.—CANADIAN MILK SAMPLING STATIONS

counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 8.

TABLE 8. TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 9 presents monthly averages of strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had <5 pc/liter.

TABLE 9. RADIONUCLIDES IN CANADIAN WHOLE MILK, OCTOBER 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Iodine-131 (pc/liter)	Strontium-90 (pc/liter)	Cesium-137 (pc/liter)
Calgary	1.10	1.5	16	27.3	124
Edmonton	1.17	1.6	17	26.2	104
Ft. William	1.10	1.6	19	49.7	202
Fredericton	1.21	1.5	2	39.8	169
Halifax	1.17	1.6	5	41.0	187
Montreal	1.10	1.7	11	24.5	103
Ottawa	1.17	1.6	5	23.3	94
Quebec	1.15	1.7	11	39.6	159
Regina	1.13	1.6	4	33.4	105
St. John's, Nfld	1.13	1.6	8	53.5	209
Saskatoon	1.17	1.6	10	31.5	93
Sault Ste. Marie	1.10	1.6	10	44.9	173
Toronto	1.15	1.6	19	14.2	69
Vancouver	1.21	1.6	3	46.1	271
Windsor	1.15	1.5	23	11.8	57
Winnipeg	1.13	1.7	28	30.9	139
Average	1.15	1.6	12	33.7	141

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO DOSE ASSESSMENT, NOVEMBER 1963–OCTOBER 1964

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) is reported on a monthly basis in *RHD.* In terms of radiological health surveillance activity, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the *PMN.* Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*3, 4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5." [1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and a 1.0 g daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allow time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its physical half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (6).

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK,[a] NOVEMBER 1963–OCTOBER 1964

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Oct 1963–Sept 1964 [a]	Nov 1963–Oct 1964 [b]	Oct 1963–Sept 1964 [a]	Nov 1963–Oct 1964 [b]	Oct 1963–Sept 1964 [a]	Nov 1963–Oct 1964 [b]	Oct 1963–Sept 1964 [a]	Nov 1963–Oct 1964 [b]
Ala:	Montgomery	3	3	23	23	0	0	36	34
Alaska:	Palmer	9	6	24	23	0	0	149	141
Ariz:	Phoenix	3	3	4	4	0	0	26	25
Ark:	Little Rock	5	4	45	45	0	0	134	129
Calif:	Sacramento	3	3	9	8	0	0	51	46
	San Francisco	4	4	10	10	0	0	58	54
C. Z:	Cristobal	3	3	5	5	0	0	48	50
Colo:	Denver	6	4	19	19	0	0	92	91
Conn:	Hartford	4	3	22	22	0	0	156	148
Del:	Wilmington	3	3	24	23	0	0	128	123
D. C:	Washington	4	3	19	19	0	0	88	86
Fla:	Tampa	3	3	16	16	0	0	241	236
Ga:	Atlanta	5	4	32	31	0	0	139	136
Hawaii:	Honolulu	4	3	11	11	0	0	80	78
Idaho:	Idaho Falls	13	11	28	27	0	0	177	168
Ill:	Chicago	4	3	20	19	0	0	118	115
Ind:	Indianapolis	4	3	22	21	0	0	100	98
Iowa:	Des Moines	8	6	26	25	0	0	95	91
Kans:	Wichita	6	5	21	21	0	0	68	66
Ky:	Louisville	6	4	32	31	0	0	94	91
La:	New Orleans	5	4	51	51	0	0	149	144
Maine:	Portland	5	3	32	31	0	0	210	201
Md:	Baltimore	5	3	22	22	0	0	103	99
Mass:	Boston	5	3	34	33	0	0	235	223
Mich:	Detroit	3	3	19	19	0	1	117	113
	Grand Rapids	4	3	21	21	0	0	127	124
Minn:	Minneapolis	11	9	33	33	0	0	154	147
Miss:	Jackson	6	5	42	41	0	0	110	107
Mo:	Kansas City	5	7	29	28	0	0	85	81
	St. Louis	7	5	23	23	0	0	85	82
Mont:	Helena	7	6	28	26	0	1	184	175
Nebr:	Omaha	9	6	27	26	0	0	90	95
Nev:	Las Vegas	8	5	10	10	0	1	78	73
N. H:	Manchester	5	3	33	32	0	0	247	236
N. J:	Trenton	4	3	19	19	0	0	118	114
N. Mex:	Albuquerque	3	3	11	11	0	1	55	54
N. Y:	Buffalo	4	3	21	20	0	0	140	141
	New York	5	4	27	26	0	0	166	159
	Syracuse	[c] 4	[d] 3	[c] 21	[d] 20	[c] 0	[d] 0	[c] 145	[d] 139
N. C:	Charlotte	5	4	36	36	0	0	115	112
N. Dak:	Minot	9	3	58	57	0	0	156	152
Ohio:	Cincinnati	4	3	24	23	0	0	94	92
	Cleveland	3	3	22	21	0	0	115	113
Okla:	Oklahoma City	4	3	23	23	0	0	72	70
Ore:	Portland	10	8	32	31	0	0	172	164
Pa:	Philadelphia	3	3	21	20	0	0	123	119
	Pittsburgh	4	3	30	29	0	0	153	148
P. R:	San Juan	3	3	13	12	0	0	74	73
R. I:	Providence	3	3	25	25	0	0	170	163
S. C:	Charleston	5	3	32	32	0	0	130	127
S. Dak:	Rapid City	11	8	43	43	0	0	156	152
Tenn:	Chattanooga	6	5	41	41	0	0	125	120
	Memphis	5	3	32	32	0	0	76	74
Tex:	Austin	3	3	9	9	0	0	42	41
	Dallas	3	3	20	20	0	0	60	66
Utah:	Salt Lake City	9	8	27	27	0	0	185	178
Vt:	Burlington	5	3	27	26	0	1	187	178
Va:	Norfolk	4	3	18	18	0	0	96	94
Wash:	Seattle	9	7	28	26	0	0	159	152
	Spokane	10	8	30	29	0	0	148	142
W. Va:	Charleston	5	4	28	27	0	0	85	81
Wis:	Milwaukee	3	3	18	18	0	0	133	130
Wyo:	Laramie	10	8	22	21	0	0	112	107
Network average		5	4	25.0	24.5	0	<10	122	118

[a] Averages computed for 52 weeks.
[b] Averages computed for 53 weeks.
[c] Averages computed for 48 weeks. No samples were collected during July 1964.
[d] Averages computed for 49 weeks. No samples were collected during July 1964.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclides concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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[2] Iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, AUGUST 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 131 stations as of January 1, 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilation (*1–7*).

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on either monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at newly established stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Strontium–90 analyses are performed on total solids of three-month composites of the weekly samples. The most recent strontium–90 results are presented in the December 1964 issue of *RHD*.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a mem-

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brane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counter.

Results

Table 1 presents August 1964 results of alpha and beta analyses of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (7). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations shown in figure 1, which gives the August 1964 average

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, AUGUST 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. M.	19	12	31	4	1	5
Arkansas River:						
Coolidge, Kansas	9	47	56	1	9	10
Ponca City, Okla	53	40	93	7	2	9
Atchafalaya River:						
Morgan City, La	9	22	31	2	2	4
Bear River:						
Preston, Idaho	1	25	26	0	2	2
Big Horn River:						
Hardin, Mont	159	32	191	61	7	68
Chena River:						
Fairbanks, Alaska	5	6	11	0	0	0
Clinch River:						
Clinton, Tenn	3	5	8	0	0	0
Kingston, Tenn	28	58	86	1	2	3
Colorado River:						
Loma, Colo	225	38	263	53	6	59
Page, Ariz	2	32	34	0	5	5
Parker Dam, Calif-Ariz	3	17	20	0	6	6
Columbia River:						
Wenatchee, Wash	5	14	19	0	0	0
Pasco, Wash	41	279	320	0	0	0
Clatskanie, Ore	19	94	113	0	0	0
Connecticut River:						
Enfield Dam, Conn	2	6	8	0	0	0
Coosa River:						
Rome, Ga	4	8	12	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	0	8	8	0	0	0
Delaware River:						
Philadelphia, Pa	5	11	16	0	0	0
Great Lakes:						
Duluth, Minn	2	4	6	0	0	0
Hudson River:						
Poughkeepsie, N.Y	8	22	30	0	1	1
Illinois River:						
Grafton, Ill	7	19	26	1	3	4
Kansas River:						
De Soto, Kans	17	34	51	3	1	4
Maumee River:						
Toledo, Ohio	5	23	28	1	0	1
Mississippi River:						
St. Paul, Minn	4	34	38	1	1	2
E. St. Louis, Ill	6	25	31	1	3	4
New Roads, La	1	15	16	0	1	1
New Orleans, La	5	23	28	0	1	1
Missouri River:						
Williston, N. Dak	1	16	17	1	3	4
St. Joseph, Mo	16	29	45	8	7	15
North Platte River:						
Henry, Nebr	8	79	87	1	14	15
Ohio River:						
Cairo, Ill	0	16	16	0	0	0
Toronto, Ohio	5	19	24	0	0	0
Platte River:						
Plattsmouth, Nebr	43	34	77	6	2	8
Potomac River:						
Washington, D.C	2	7	9	0	1	1
Red River, North:						
Grand Forks, N. Dak	1	55	56	0	4	4
Red River, South:						
Alexandria, La	2	27	29	1	0	1
Rio Grande River:						
El Paso, Tex	1	31	32	0	1	1
Laredo, Tex	59	25	84	6	1	7
San Joaquin River:						
Vernalis, Calif	17	17	34	1	9	10
San Juan River:						
Shiprock, N. Mex	971	39	1010	229	2	231
Savannah River:						
Port Wentworth, Ga	9	20	29	<1	<1	<1
Snake River:						
Wawawai, Wash	1	5	6	0	2	2
South Platte River:						
Julesburg, Colo	2	52	54	0	16	16
Susquehanna River:						
Conowingo, Md	7	15	22	0	0	0
Tennessee River:						
Chattanooga, Tenn	0	6	6	1	0	1
Wabash River:						
New Harmony, Ind	4	12	16	0	1	1
Yellowstone River:						
Sidney, Mont	39	20	59	12	3	15
Maximum	971	279	1010	229	16	231
Minimum	0	4	6	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

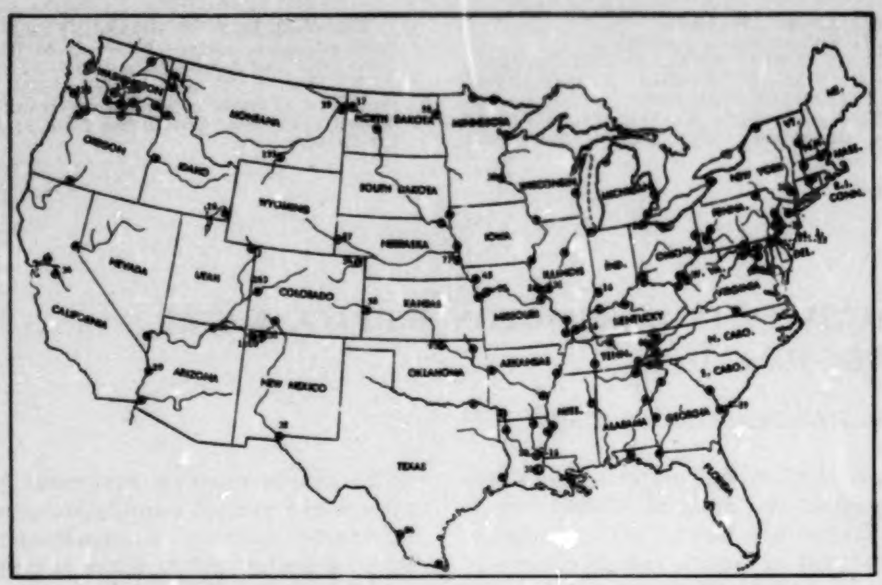
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Figure 1.—SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, AUGUST 1964

total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the years 1957–1962 have been summarized by Weaver *et al* (*9*). Floyd and Weaver summarized the strontium-90 results obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*10*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter at only one station, the Pasco, Washington station on the Columbia River.

Dissolved alpha activity, associated with the dissolving of natural surface minerals by water, ranged from 0 to 16 pc/liter. Two stations on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

Analysis of the preliminary August 1964 data indicates elevated levels of alpha and beta activity (pc/liter) in the suspended solids fraction. The monthly average suspended alpha and beta activities in the San Juan River at Shiprock, New Mexico were 229 and 971 pc/liter, respectively. The dissolved alpha and beta activities were not significantly different from those commonly observed at this sampling station. The samples associated with these unusually high averages contained large quantities of suspended solids. Thus, only quite small aliquots could be used in the laboratory determinations to avoid excessive beta self-absorption. In such cases the relatively large multiplication factor, together with the usual range of counting errors associated with standard counting periods, can result in apparently abnormal levels of radioactivity. The specific activity (pc/g) of the samples discussed above was determined and found to be comparable to specific activity observed normally in samples from this station. The apparent increased activity, therefore, may be attributed to the extremely high suspended solids content of the sample and considered essentially of natural origin.

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RADIOACTIVITY IN WASHINGTON SURFACE WATER,[1] JULY 1963–JUNE 1964

Washington State Department of Health

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Most surface water samples are collected quarterly from 70 stations located on 59 rivers throughout the State. These samples are collected by the Washington Pollution Control Commission and are sent to the Department of Health for radiological analyses. A few locations are sampled less frequently, and selected stations on the Columbia River are sampled weekly by local health department sanitarians. All surface water samples are collected as grab samples in a 2-liter plastic bottle. Two milliliters of concentrated nitric acid are added to the sample before shipment to the laboratory to prevent loss of activity to the container.

Analytical Procedures

Surface water samples are placed in stainless steel Marinelli beakers for the gamma analyses. Distilled water is added when necessary to obtain 2-liter volumes for standardizing counting geometry. These samples are gamma scanned for 100 minutes approximately two weeks after collection. This two-week period permits the decay of short-lived isotopes (Na^{24}, As^{76}, Np^{239}) in Columbia River water samples. The matrix method, utilizing a 4 x 4 matrix, permits the estimation of Cr^{51}, Ru^{106}, Zr^{95}, and Zn^{65}. Results are extrapolated to the date of collection.

The gamma-counting equipment consists of a 3 x 3-inch gamma scintillation crystal and a 512-channel analyzer. A one-minute count each day of a cesium–137 standard is performed as an efficiency check, and a ten-minute count each week is done to check the resolution. An 800-minute count each week is taken to check the background. Table 1 gives the gamma efficiencies and detectability limits for this system.

After the gamma scan, the water samples receive further preparation and are beta counted approximately eighteen days after sample collection for suspended and soluble radioactivity. The separation of dissolved and suspended activity is accomplished by filtering the acidified sample (Wattman #42 filter paper). The filtrate, evaporated to near dryness, is quantitatively transferred to a tared planchet and dried for gross beta counting. The filter paper containing the suspended matter is ashed in a muffle furnace at 600° C and transferred to a planchet for gross beta counting.

TABLE 1. BETA AND GAMMA EFFICIENCIES AND DETECTABILITY LIMITS FOR THE WASHINGTON STATE ANALYSES

Radionuclide	Energy band (Mev)	Efficiency (%)	Average background (pc)	Detectability limits (pc)
Beta				
Sr^{90}-Y^{90}	—	33	0.68	0.27
Y^{90}	—	37	0.61	0.24
P^{32}	—	31	0.73	0.29
Gamma				
Cs^{137}	0.62-0.72	2.50	230	30
Cr^{51}	0.30-0.36	0.45	2,600	220
Ru^{106}	0.44-0.56	0.94	1,300	100
Zr^{95}	0.73-0.79	6.00	51	10
Zn^{65}	1.05-1.17	0.94	340	50

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[1] Summarized from *Environmental Radiation Surveillance in Washington State*, (1).

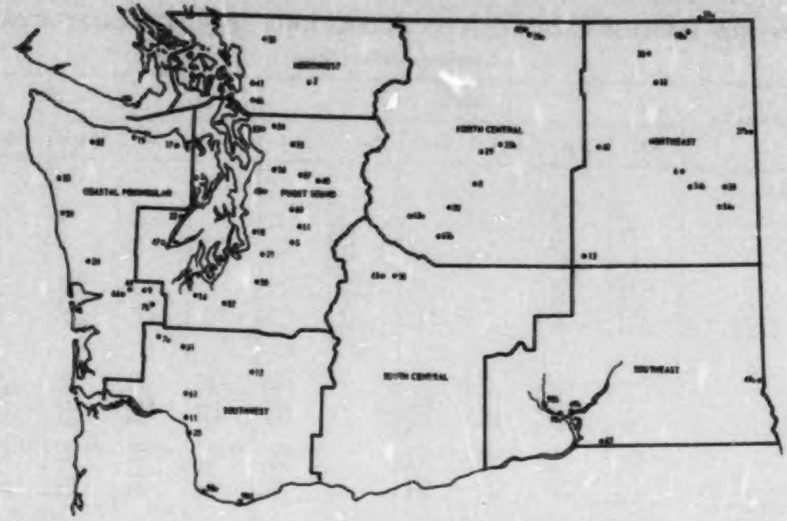

FIGURE 1.—WASHINGTON SURFACE WATER SAMPLING LOCATIONS WITH CODE NUMBERS

Counting time is 100 minutes. After obtaining the net beta counting rate, corrections for self absorption are made and the results converted to concentrations in water. Gross beta results are not extrapolated to date of collection.

In addition to the above analyses, water samples from the Columbia River are also analyzed for P^{32}. The technique used for P^{32} separation is a modification of published methods (2, 3, 4, 5). After the sample has been stored for fifteen days, which allows As^{76} and other short-lived interfering radionuclides to decay, the phosphorus is separated by precipitation as ammonium phosphomolybdate from a dilute acid medium. The precipitate is washed with ammonium nitrate, transferred into a tared planchet, ashed, weighed, and counted for beta activity. The counting rate is corrected for self absorption, P^{32} efficiency, and the decay rate. The results are converted to concentrations in water.

Beta counting is done with a low background beta system including a 2-inch detector and automatic sample changer. This system has an average background of 0.5 counts per minute. Background counts are performed as an integral part of each sample. Gross beta calibration of the instrument is done with a Sr^{90}–Y^{90} standard.

Results

Table 2 presents the monthly average results for the Columbia River Stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to one half the numerical value.

Table 3 summarizes the beta activity measurements from the 65 other surface water stations from July 1963 through June 1964. The first column in this table gives code numbers and the abbreviations denoting geographical sections (in figure 1). Each river is assigned a number and if more than one station is located on that river, lower case letters are used to designate these stations. For example, code number 21 refers to the Green River sampling station in the area designated "PS", i.e. Puget Sound. The third column gives the total number of samples analyzed.

Gamma scans of the samples in table 3 indicated no detectable activity except in four samples. Among there four samples, Ru^{106} concentrations ranged to 107 pc/liter, and Zr^{95} concentrations ranged to 11 pc/liter.

The network summary gives the maximum and minmum values for the 224 samples analyzed, while the network average is obtained by averaging all the station average values.

TABLE 2.—MONTHLY AVERAGE RADIOACTIVITY IN COLUMBIA RIVER WATER, JULY 1963–JUNE 1964

[Concentrations in pc/liter]

Location and type of analysis	1963						1964					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	June
Northport (Code No. 90a)												
Beta												
Suspended [a]	2	2	[b] —	—	2	—	—	—	1	—	—	1
Dissolved [a]	19	21	—	—	20	—	—	—	8	—	—	10
Total [a]	21	23	—	—	25	—	—	—	9	—	—	11
Phosphorus-32 [c]	<1	<1	—	—	<1	—	—	—	<1	—	—	<1
Gamma [c]												
Chromium-51	<110	<110	—	—	<110	—	—	—	<110	—	—	<110
Ruthenium-106 [d]	<50	<50	—	—	<50	—	—	—	<50	—	—	<50
Zirconium-95	<5	<5	—	—	<5	—	—	—	<5	—	—	<5
Zinc-65	<35	<25	—	—	<25	—	—	—	<25	—	—	<25
Pasco (Code No. 90e)												
Beta												
Suspended [a]	10	32	51	21	—	16	33	31	37	52	14	16
Dissolved [a]	34	70	146	236	—	195	101	171	203	282	56	43
Total [a]	44	102	197	257	—	235	104	202	233	334	70	59
Phosphorus-32 [c]	27	86	166	476	—	289	230	236	211	366	53	59
Gamma [c]												
Chromium-51	4,796	8,309	7,028	23,890	—	14,831	11,507	10,927	13,020	17,293	2,251	1,003
Ruthenium-106 [d]	78	<50	70	82	—	67	95	53	93	132	<50	<50
Zirconium-95	6	<5	<5	<5	—	6	<5	<5	<5	7	<5	<5
Zinc-65	138	140	235	278	—	243	296	218	192	240	149	92
Richland (Code No. 90b)												
Beta												
Suspended [a]	—	—	—	—	—	—	—	—	—	117	130	19
Dissolved [a]	—	—	—	—	—	—	—	—	—	334	271	80
Total [a]	—	—	—	—	—	—	—	—	—	451	401	99
Phosphorus-32 [c]	—	—	—	—	—	—	—	—	—	522	369	114
Gamma [c]												
Chromium-51	—	—	—	—	—	—	—	—	—	11,713	6,471	2,794
Ruthenium-106 [d]	—	—	—	—	—	—	—	—	—	222	133	<100
Zirconium-95	—	—	—	—	—	—	—	—	—	<10	18	<10
Zinc-65	—	—	—	—	—	—	—	—	—	580	599	158
Vancouver (Code No. 90c)												
Beta												
Suspended [a]	14	12	7	8	11	10	12	9	18	19	26	15
Dissolved [a]	28	28	31	41	44	62	52	57	60	56	54	32
Total [a]	42	40	38	49	55	72	64	66	78	75	80	47
Phosphorus-32 [c]	24	24	15	25	43	76	61	90	63	76	81	41
Gamma												
Chromium-51	1,686	3,712	3,913	4,455	4,479	4,901	3,842	4,037	3,880	2,834	2,228	1,192
Ruthenium-106 [d]	<50	<50	<50	109	<50	<50	<50	<50	<50	<50	<50	<50
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zinc-65	56	40	<25	35	<25	49	49	55	59	62	93	66
Washougal (Code No. 90d)												
Beta												
Suspended [a]	15	12	7	9	11	10	17	11	16	19	24	13
Dissolved [a]	28	28	31	42	48	62	56	66	54	64	55	33
Total [a]	43	40	38	51	59	72	73	77	70	82	79	46
Phosphorus-32 [c]	23	23	14	28	40	78	60	83	59	79	82	39
Gamma [c]												
Chromium-51	1,803	3,782	3,850	4,671	5,355	5,272	4,532	4,484	4,284	3,038	2,280	1,345
Ruthenium-106 [d]	<50	<50	<50	87	<50	<50	<50	<50	<50	<50	<50	<55
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zinc-65	60	31	<25	35	<25	43	53	69	49	62	98	59

[a] Activity at time of counting. Sr^{90}–Y^{90} calibration standard in suspended and dissolved solids acidified.
[b] Dash indicates no sample.
[c] Results extrapolated to date of collection.
[d] Net activity in the 0.44–0.56 mev gamma range is assumed to be only Ru^{106}.

Discussion

Of the 224 river water samples analyzed from July 1963 through June 1964 (excluding the Columbia River), the total beta activity ranged from 1 to 89 pc/litter with an average of 11.8 pc/liter. The activity of the soluble fraction was somewhat lower, ranging from 1 to 59 pc/liter and averaging 9.5 pc/liter. These network averages during the June 1963 through July 1964 period were lower by about a factor of two than the averages for the preceding twelve months.

Monthly average total beta activity for the Columbia River stations below the Hanford Facility ranged from 38 to 451 pc/liter. Monthly average concentrations of the beta-emitter, P^{32}, in the Columbia river water samples taken below the Hanford Facility ranged from 14 to 522 pc/liter.

The radionuclides Ru^{106} and Zr^{95} were found in monthly average concentrations that ranged from <50 to 222 pc/liter for Ru^{106}, and <5 to 18 pc/liter for Zr^{95}. The values for Ru^{106} are probably a combination of Ru^{103} and Ru^{106}. The

TABLE 3.—BETA ACTIVITY IN WASHINGTON SURFACE WATER, JULY 1963–JUNE 1964

[Concentrations in pc/liter]

Code number and area		Sampling location (river)	Number of samples	Suspended			Dissolved			Total		
				Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
2	NW	Baker	4	2	<1	3	13	9	15	15	9	17
3	PS	Big Quilcene	2	<1	<1	<1	4	2	5	4	2	5
5	PS	Cedar	12	2	<1	9	7	2	26	9	3	35
7a	SW	Chehalis	4	1	<1	4	9	6	[illegible]	10	6	18
7b	CP	Chehalis	3	1	<1	2	8	6	11	9	8	12
8	NC	Chelan	4	<1	<1	<1	6	5	8	6	5	8
9	CP	Cloquallam	4	<1	<1	<1	6	4	[illegible]	6	4	8
10	NE	Colville	4	2	<1	3	10	7	16	12	7	16
11	SW	Coweman	4	1	<1	5	6	3	10	7	3	11
12	SW	Cowlitz	3	<1	<1	<1	5	4	9	6	4	9
14	PS	Deschutes	2	2	2	2	7	5	8	9	7	10
15	PS	Dosewallips	2	3	<1	5	8	5	10	10	5	15
16	PS	Duckabush	2	1	<1	2	7	4	9	8	4	11
17	CP	Dungeness	2	3	3	4	7	4	9	10	6	13
18	PS	Duwamish	4	3	<1	6	9	4	13	12	4	16
19	CP	Elwha	2	2	1	2	8	5	7	8	6	10
20	NC	Entiat	4	1	<1	2	6	4	8	7	4	10
66	PS	Ft. Lewis	2	<1	<1	<1	3	2	3	3	2	3
21	PS	Green	4	3	<1	4	8	3	14	10	3	17
22	PS	Hamma Hamma	2	<1	<1	<1	3	2	4	3	2	4
23	CP	Hoh	2	17	[illegible]	32	23	14	31	40	16	63
24	CP	Humptulips	4	3	<1	11	10	3	16	13	3	27
25	SW	Kalama	4	1	<1	2	5	3	8	7	3	9
26	NE	Kettle	4	<1	<1	1	8	6	10	9	6	11
28	NE	Little Spokane	4	1	<1	2	10	8	13	11	8	15
29	NC	Methow	4	1	<1	2	5	4	8	6	4	10
31	SW	Newaukum	4	1	<1	3	7	5	8	8	6	11
32	PS	Nisqually	4	1	<1	2	11	10	13	12	10	14
33	NW	Nooksak	4	10	<1	20	16	5	29	26	5	40
34	PS	N. Stillaguamish	3	1	<1	3	8	6	10	10	6	13
35a	NC	Okanogan	2	2	1	2	15	14	15	16	15	17
35b	NC	Okanogan	4	1	<1	4	11	8	15	12	8	19
37a	NE	Pend Oreille	4	1	<1	3	10	8	12	12	9	13
37b	NE	Pend Oreille	5	<1	<1	1	10	8	15	10	8	15
38	PS	Puyallup	4	10	<1	30	24	3	59	33	3	89
39	CP	Queets	2	16	2	29	17	12	21	32	14	50
67	CP	Quinault	2	1	<1	2	9	7	11	10	7	13
41	NW	Samish	4	3	<1	6	9	6	15	12	6	21
42	NE	Sanpoil	4	<1	<1	<1	6	4	9	6	4	9
43	PS	Sammamish	4	4	3	4	14	8	19	18	11	23
44	CP	Satsop	4	4	<1	14	8	3	12	13	3	26
45	NC	Similkameen	2	1	<1	2	10	5	14	11	5	16
46	NW	Skagit	4	12	1	39	19	7	43	31	8	82
47	PS	Skokomish	2	2	<1	4	5	1	9	7	1	13
48	PS	Skykomish	4	1	<1	3	11	5	17	13	5	19
49a	SE	Snake	4	1	<1	1	11	9	14	12	9	15
49b	SE	Snake	2	3	2	4	13	12	14	16	14	18
50	PS	Snohomish	4	1	<1	3	11	7	19	12	7	22
51	PS	Snoqualmie	4	2	<1	6	11	7	15	13	7	19
52	CP	Soleduck	2	3	<1	5	9	4	13	11	4	18
53	PS	S. Stillaguamish	4	3	1	5	11	6	14	13	7	19
54a	NE	Spokane	4	1	<1	2	10	7	11	10	7	13
54b	NE	Spokane	4	<1	<1	1	8	7	10	8	7	10
55	PS	Stillaguamish	3	2	1	2	8	6	9	9	7	11
56	PS	Stuck	3	1	<1	2	15	10	24	17	10	26
57	PS	Sultan	4	2	<1	3	9	6	10	10	6	13
58	SC	Teanaway	2	2	<1	4	5	3	7	7	3	11
60	PS	Tolt	4	2	<1	3	10	8	13	11	8	16
61	SW	Toutle	4	1	<1	3	8	4	11	10	4	14
62	SE	Walla Walla	2	4	3	4	13	9	16	16	13	19
63a	NC	Wenatchee	3	<1	<1	<1	10	9	11	10	9	11
63b	NC	Wenatchee	4	1	<1	3	10	8	14	11	8	15
64	CP	Wynoochee	4	4	<1	14	8	3	16	12	3	30
65	SC	Yakima	3	<1	<1	2	10	5	9	11	5	11
Network summary			224	2.5	<1	39	9.5	1	59	11.8	1	89

radionuclides Ru^{106} and Zr^{95} were found in four samples from other river basins as well as in the Columbia River. Two other radionuclides, Cr^{51} and Zn^{65}, were found in detectable quantities only in Columbia River water. Monthly averages for Cr^{51} ranged from 1,192 to 23,899 pc/liter, and for Zn^{65} the range was <25 to 599 pc/liter.

Although any standards for gross beta activity must be very carefully applied, the standard for drinking water is 1,000 pc/liter of beta activity in the absence of strontium-90 and alpha emitters (*6*). The standards for water from all dietary sources for the general population at large (*7*) are:

Cr^{51}, 670,000 pc/liter; Ru^{106}, 3,300 pc/liter; Zr^{95}, 20,000 pc/liter; Zn^{65}, 10,000 pc/liter; P^{32}, 7,000 pc/liter.

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Section IV—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors periodic reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC installations have appeared periodically in *RHD* since November 1960. Following are reports for Paducah Plant, Pinellas Peninsula Plant, and the Savannah River Plant.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set forth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are identical to those published in the Federal Register (*1*).

1. Paducah Plant, January–June 1964

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by Union Carbide Corporation Nuclear Division for the Atomic Energy Commission. The diffusion plant, with the associated uranium hexafluoride manufacturing plant and uranium metal foundry, processes large quantities of relatively pure uranium compounds. The major sources of external penetrating radiation are the uranium daughter products, thorium-234, and protactinium-234, which are concentrated in the ash produced during the fluorination process. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Uranium is a rather expensive element, and this provides a great incentive to recover as much in any situation as is feasible. The added desire to maintain a wholesome relationship with neighboring communities and individuals makes it essential that all entrained dust be filtered from exhaust systems, and that all effluent waters be maintained at extremely low concentrations of uranium.

Since no recovery process or filtering system is 100 percent efficient, an environmental monitoring program is required to evaluate the effectiveness of such measures. The Paducah Plant environmental monitoring program provides for continuously sampling the air at 4 stations around the plant perimeter fence, at 5 stations located approximately 1 mile outside this fence, and at 4 stations located 5 miles from the plant. Big Bayou Creek water is sampled continuously, and grab samples are collected at 5 locations in the Ohio River. In addition, gamma radiation readings are taken at each of the air sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

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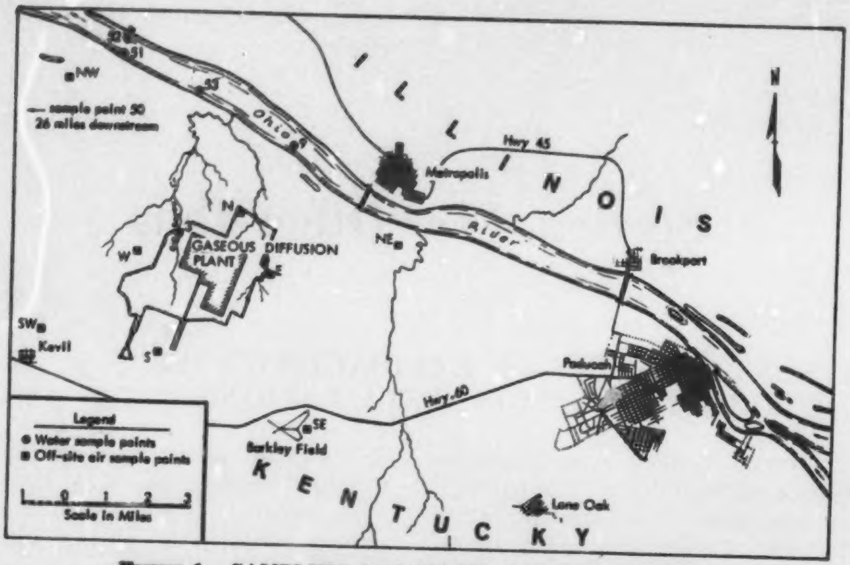

FIGURE 1.—SAMPLING LOCATIONS, PADUCAH PLANT

Basic Standards

The standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for off-site exposure of the general population, are those listed in AEC Appendix 0524 which are in turn based on those documented by the Federal Radiation Council in the Federal Register (*1*) on May 18, 1960, and by the National Committee on Radiation Protection in NBS Handbook 69 (*2*). Guidance on general principles of control applicable to all radionuclides occurring in the environment is contained in Report No. 2 of the Federal Radiation Council (*3*). (The references follow Savannah River Plant report).

The standards specify that the radiation or radioactive materials outside a controlled area, and which have resulted from operations within the controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5-rem in any year. To meet this standard the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion of Data

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 1 through 5.

TABLE 1. OUTDOOR URANIUM AIR SAMPLES, FIRST HALF OF 1964

Sample location [a]	No. of samples	Uranium alpha,[b] (pc/m³)			Mean as percent of RCG [d]
		Max.	Min.[c]	Mean	
AT PLANT PERIMETER FENCE					
N	26	0.19	<0.02	0.039	2.0
E	26	0.25	<0.02	0.027	1.4
S	26	0.05	<0.02	0.013	0.7
W	26	0.06	<0.02	0.013	0.7
Totals	104	0.25	<0.02	0.023	1.2
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE					
N	26	0.037	<0.02	0.013	0.7
E	26	0.028	<0.02	0.01	0.5
S	26	0.033	<0.02	0.012	0.6
W	26	0.019	<0.02	0.007	0.4
SE	26	0.033	<0.02	0.008	0.4
Totals	130	0.037	<0.02	0.01	0.5
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE					
SW	26	0.033	<0.02	0.011	0.6
NW	26	0.128	<0.02	0.023	1.2
NE	26	0.122	<0.02	0.024	1.2
SE	26	0.067	<0.02	0.019	1.0
Totals	104	0.128	<0.02	0.019	1.0

[a] See map in figure 1.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.49 x 10^4 alpha dis/sec.

[c] The minimum detectable uranium in air is 0.02 pc/m³.

[d] The RCG for natural uranium in air beyond a controlled area is 2 pc/m³. (AEC Appendix 0524, Annex 1, table II.).

TABLE 2. OUTDOOR BETA AIR SAMPLES, FIRST HALF OF 1964

Sample location [a]	No. of samples	Beta (pc/m^3)			Means as percent of RCG [c]
		Max.	Min.[b]	Mean	
AT PLANT PERIMETER FENCE					
N	26	11	0.4	4.1	0.4
E	26	6	0.4	2.5	0.3
S	26	2.7	<0.075	1.2	0.1
W	26	5	0.4	1.5	0.2
Totals	104	11	<0.075	2.3	0.2
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE					
N	26	3	0.4	1.5	0.2
E	26	3	0.4	1.3	0.1
S	26	3	0.4	1.3	0.1
W	26	3	0.4	1.2	0.1
SE	26	3	0.4	1.2	0.1
Totals	130	3	0.4	1.3	0.1
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE					
SW	26	2	0.4	1.2	0.1
NW	26	3	0.9	1.5	0.2
NE	26	3	0.4	1.5	0.2
SE	26	3	0.4	1.3	0.1
Totals	104	3	0.4	1.4	0.1

[a] See map in figure 1.

[b] The minimum detectable amount of beta emitters in air is 0.075 pc/m^3.

[c] The RCG applicable to this table is 1,000 pc/m^3, this number is the RCG for thorium-234, the daughter product of U-238. Insignificant amounts of other daughters are present in freshly refined uranium.

TABLE 3. CONCENTRATION OF URANIUM IN WATER, FIRST HALF OF 1964

Sample location [a]	No. of samples	Uranium, (pc/liter)[b]			Mean as percent of RCG [d]
		Max.	Min.[c]	Mean	
BIG BAYOU CREEK 3	26	59	<1	20	0.1
OHIO RIVER 9	5	1	<1	<1	<0.01
Composite of 50, 51, 52, & 53	5	2	<2	<1	<0.01

[a] See map in figure 2.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.49 x 10^4 dis/sec.

[c] The minimum detectable uranium in water is 1 pc/liter.

[d]. The RCG for natural uranium in water beyond a controlled area is 20,000 pc/liter. (AEC Appendix 0524, Annex 1, table II).

TABLE 4. CONCENTRATION OF BETA EMITTERS IN WATER, FIRST HALF OF 1964

Sample location [a]	No. of samples	Beta emitters, pc/liter			Mean as percent of RCG[c]
		Max.	Min.[b]	Mean	
BIG BAYOU CREEK 3	26	2100	<100	400	2.0
OHIO RIVER 9	5	700	<100	300	1.5
Composite of 50, 51, 52 & 53	5	1800	<100	400	2.0

[a] See map in figure 1.

[b] The minimum detectable amount of beta emitters in water is 100 pc/liter.

[c] The RCG for the daughter products of uranium in water beyond a controlled area is 20,000 pc/liter. (AEC Appendix 0524, Annex 1, table II).

Air samples were collected continuously at each of 4 stations at the plant perimeter fence, at 5 stations at about 1 mile outside the plant, and at 4 stations located about 5 miles from the plant. Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta activity.

The average alpha count, interpreted as uranium—the most likely source of activity, of the 338 air samples collected was 0.9 percent of the Radioactivity Concentration Guide (RCG) for people residing in the vicinity of a controlled area.

TABLE 5. EXTERNAL GAMMA RADIATION LEVELS FIRST HALF OF 1964

Air sampling location [a]	Total No. of readings	Gamma, mr/hour
AT PLANT PERIMETER FENCE		
N	6	0.02
E	6	0.02
S	6	0.02
W	6	0.02
Totals	24	0.02
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE		
N	6	0.02
E	6	0.02
S	6	0.02
W	6	0.02
SE	6	0.02
Totals	30	0.02
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE		
SW	6	0.02
NW	6	0.02
NE	6	0.02
SE	6	0.02
Totals	24	0.02

[a] See map in figure 1.

The mean beta count of the 338 samples was 0.18 percent of the RCG for the daughter products of uranium in air beyond a controlled area.

The average uranium analysis of 26 weekly water samples collected by a continuous water sampler in the Big Bayou was 0.1 percent of the RCG for water beyond a controlled area. The uranium analysis of each of 5 samples collected from the Ohio River below the plant at monthly intervals (except during the March flood) was less than 0.02 percent of the RCG. The average beta analysis for the 26 samples from the Big Bayou was 2 percent of the RCG for the decay products of uranium in water beyond a controlled area. The average beta analysis for the 5 samples of Ohio River water downstream from the plant was also 2 percent of the RCG when interpreted as uranium daughters. However, similar samples of upstream water averaged 1.5 percent of this RCG.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mr/hour at all sampling stations.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*August 1962*
1962	*September 1963*
1963	*July 1964*

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2. Pinellas Peninsula Plant, January–June 1964

General Electric Company,
St. Petersburg, Florida

Pinellas Peninsula Plant, shown in figure 2, is an electronic component production facility in the Atomic Energy Commission's Albuquerque Operations Office manufacturing complex. Environmental monitoring includes sampling of a single combined sewer effluent, milk from five local dairy farms, air, and surface water obtained at locations suggested by meteorological conditions and radioactivity discharge concentrations. Except for air samples which may also contain tritium gas, the radioactive portion of the samples is essentially tritium oxide.

Air Monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack revealed no detectable amounts of tritium gas or tritium oxide. The limit of detection is 9,600,000 pc/m³ of tritium gas or 5,000 pc of tritium oxide per cubic meter of air.

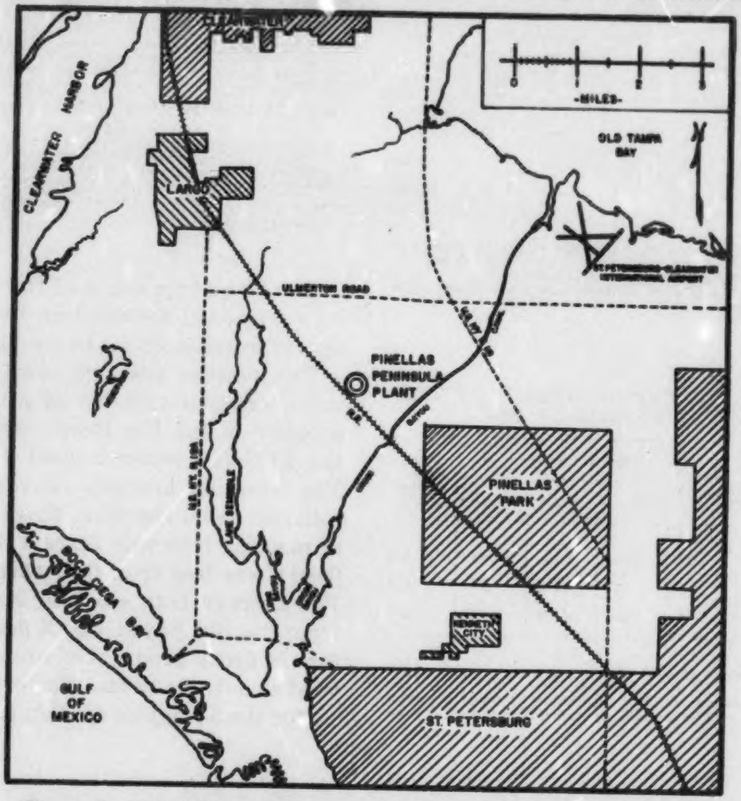
CLEARWATER
0
1
2
3
-MILES-
CLEARWATER HARBOR
OLD TAMPA BAY
LARGO
ST. PETERSBURG-CLEARWATER INTERNATIONAL AIRPORT
ULMERTON ROAD
PINELLAS PENINSULA PLANT
PINELLAS PARK
LAKE SEMINOLE
BOCA CIEGA BAY
KENNETH CITY
GULF OF MEXICO
ST. PETERSBURG

FIGURE 2.—LOCATION OF THE PINELLAS PENINSULA PLANT

Water Sampling

A combined sewer effluent sample is obtained daily from beyond the perimeter of the plant's property. There were no detectable concentrations of tritium oxide (>790,000 pc/liter) in the 128 samples analyzed during the sampling period.

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium (>90,000 pc/liter) in 51 surface water samples analyzed during the sampling period.

Milk Sampling Results

Twenty-four samples of raw milk were collected from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1963. No detectable concentrations (>90,000 pc/liter) of tritium oxide were evident.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960–1961	July 1962
Calendar year 1962	June 1963
Calendar year 1963	September 1964

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[1] Expressions in parentheses indicate limits of detectability in the respective environmental samples.

3. Savannah River Plant, January–June 1964

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Georgia. Production facilities include a Fuel Preparation area, five Reactors, two Fuel Separation areas, and a Heavy Water Production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to insure environmental concentrations below recommended guides.

The Du Pont Health Physics Section has maintained a continuous monitoring program since 1951 (prior to plant startup) to determine the concentrations of radioactive materials in a 1200-square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the Maximum Permissible Concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the Daily Intake Guides recommended by the Federal Radiation Council (FRC).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity cannot readily be distinguished from weapons tests fallout and both are included in the reported concentrations; maximum and minimum values given are for individual samples collected during the report period.

Atmospheric Monitoring

Concentrations of radioactive materials in the atmosphere were measured by weekly analyses of air filters collected at five monitoring stations located on the plant perimeter and ten stations around a circle of about 25 miles radius from the center of the plant (see figure 3). Deposition rates of radioactive materials at each station were also determined by monthly analyses of rainwater ion-exchange columns (fallout collectors). The monitoring stations are spaced so that a significant plant release of airborne activity would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina, are so distant from the plant that

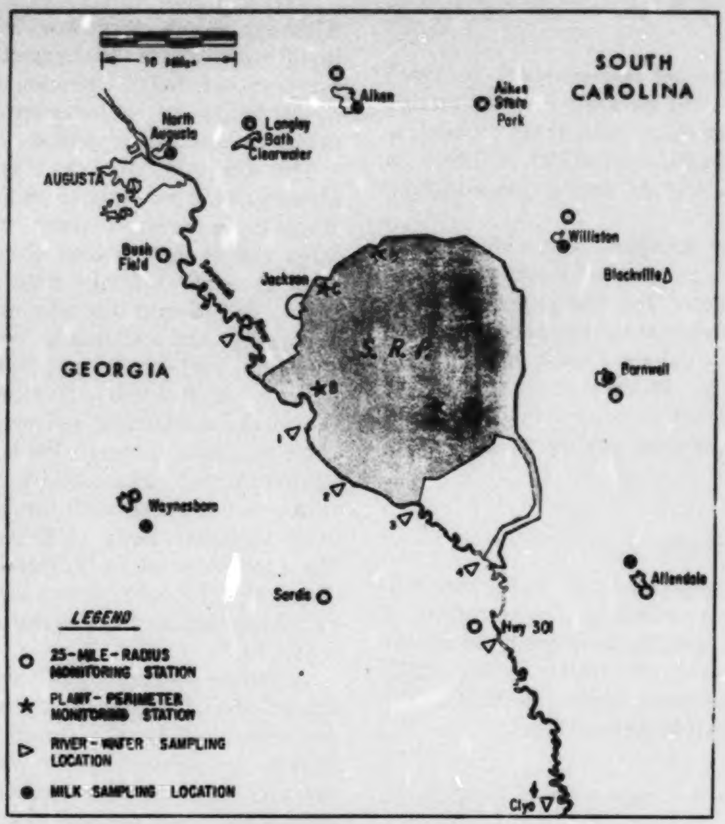
10 Miles
SOUTH CAROLINA
Aiken
Aiken State Park
North Augusta
Langley Bath Clearwater
AUGUSTA
Williston
Bush Field
Savannah River
Jackson
C
Blackville
S. R. P.
GEORGIA
B
Barnwell
1
2
3
4
Waynesboro
Allendale
Sardis
Hwy 301
Clyo
LEGEND
25-MILE-RADIUS MONITORING STATION
PLANT-PERIMETER MONITORING STATION
RIVER-WATER SAMPLING LOCATION
MILK SAMPLING LOCATION

FIGURE 3.—ENVIRONMENTAL SAMPLING LOCATIONS, SAVANNAH RIVER PLANT

the effect of SRP operations is negligible; they are reference points for determining background activity levels (see figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and plant releases.

The small amount of radioactive materials released to the atmosphere from the Fuel Separations areas was obscured by fallout from nuclear weapons tests. The influence of the weapons tests which resumed in September 1961 are shown in figure 5. Even though the atmospheric weapons test moratorium began in December 1962, airborne radioactivity continues to remain above the pre-September 1961 concentrations. The rise in levels of airborne radioactivity in early 1964 was the result of the anticipated spring increase in the mixing of stratospheric debris into the troposphere.

Radioactivity in air, determined from filter analyses, is shown in table 6. The January-June 1964 concentrations of beta activity (1.1 pc/m^3) and alpha activity (0.001 pc/m^3) in air were 1.1 percent and 2.5 percent of the respective MPC. Iodine-131 concentrations in air samples were less than 0.02 pc/m^3, the lower detection limit. The relative abundance of airborne radionuclides since January 1963 is shown in figure 6. The diminishing activity is proportional to the areas of the circles which show average activity for each six-month period. Aging of the fallout is seen from increasing percentages of the longer-lived radionuclides Sr^{90}, Cs^{137}, and Ru^{106}. The concentration of beta activity in air was 40 percent below the preceding 6-month period, but because of a combination of unusually high rainfall and increased tropospheric radioactivity during the spring months, the amount of radioactivity de-

TABLE 6.—RADIOACTIVITY IN AIR

(Filter analyses)

	Plant-perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Avg	Aiken Air-port	Aiken State Park	Allen-dale	Barn-well	Bush-Field	High-way 301	Lang-ley	Sar-dis	Waynes-boro	Will-iston	Avg
Alpha Emitters in Air pc/m^3 (multiply by 10^{-3})[a]																	
Max	1.5	1.6	2.6	2.0	2.0		2.2	1.6	2.4	1.7	1.6	1.4	2.4	2.5	1.9	1.8	
Min	0.5	0.5	[c]	0.3	[c]		[c]	0.4	0.4	0.1	0.4	0.5	0.5	0.4	0.4	0.6	
Avg	1.0	1.0	1.3	0.9	1.0	1.0	1.1	0.9	1.1	0.9	1.0	0.8	1.4	1.2	1.0	1.2	1.0
Nonvolatile Beta Emitters in Air (pc/m^3)[b]																	
Max	1.9	2.1	2.9	1.9	2.0		2.2	2.1	1.9	1.8	2.0	1.6	2.1	1.7	2.0	1.9	
Min	0.6	0.6	0.6	0.5	0.6		0.6	0.4	0.6	0.6	0.5	0.7	0.5	0.6	0.6	0.7	
Avg	1.1	1.1	1.2	1.1	1.1	1.1	1.2	1.1	1.1	1.1	1.1	0.9	1.1	1.1	1.2	1.2	1.1
Specific Radionuclides in Air (Averages) pc/m^3																	
Cs^{137}	0.11	0.12	0.14	0.11	0.12	0.12	0.12	0.12	0.11	0.12	0.11	—	0.11	0.11	0.11	0.12	0.11
Ce^{144}	.62	.61	.71	.62	.62	.64	.63	.62	.61	.64	.62	—	.58	.60	.63	.63	.62
Ru^{106}	.53	.54	.60	.59	.55	.56	.54	.54	.53	.54	.54	—	.50	.50	.56	.57	.54
Zr-Nb^{95}	.13	.13	.15	.13	.14	.14	.13	.13	.13	.12	.12	—	.12	.12	.13	.13	.12
Mn^{54}	0.09	0.07	0.08	0.09	0.07	0.07	0.08	0.08	0.07	0.08	0.08	—	0.07	0.08	0.10	0.08	0.08

	Distant air-monitoring locations										
	Columbia, S.C.	Greenville, S.C.	Macon, Ga.	Savannah, Ga.	Avg		Columbia S.C.	Greenville, S.C.	Macon, Ga.	Savannah, Ga	Avg
Alpha Emitters in Air, pc/m^3 (multiply by 10^{-3})[a]						Nonvolatile Beta Emitters in Air (pc/m^3)[b]					
Max	2.7	2.1	3.0	2.9			3.0	2.3	1.8	2.8	
Min	0.5	0.4	0.4	0.2			0.6	0.5	0.5	0.4	
Avg	1.2	1.0	1.2	1.2	1.2		1.1	1.1	1.1	1.2	1.1
Specific Radionuclides in Air (Averages), pc/m^3											
Cs^{137}	0.11	0.11	0.11	0.11	0.11						
Ce^{144}	.58	.62	.60	.60	.60						
Ru^{106}	.49	.52	.52	.51	.51						
Zr-Nb^{95}	.12	.12	.13	.12	.12						
Mn^{54}	0.07	0.07	0.07	0.07	0.07						

[a] MPC=40; Sensitivity of analysis, 0.2.

[b] MPC=100; sensitivity of analysis, 0.006.

[c] Less than sensitivity of analysis.

posited on the ground was relatively unchanged. Deposition of radioactive materials during the first half of 1964 totaled 366 mc/sq mi at plant perimeter locations and 343 mc/sq mi at 25-mile radius locations; comparable values for the last half of 1963 were 250 mc/sq mi and 390 mc/sq mi. Deposition at each sampling location is recorded in table 7.

Vegetation

Radioactive contamination of vegetation may result from direct deposition on exposed surfaces or from sorption of radioactivity from the soil. Bermuda grass was selected for analysis because of its importance as a pasture grass for daily herds and its availability during all seasons of the year.

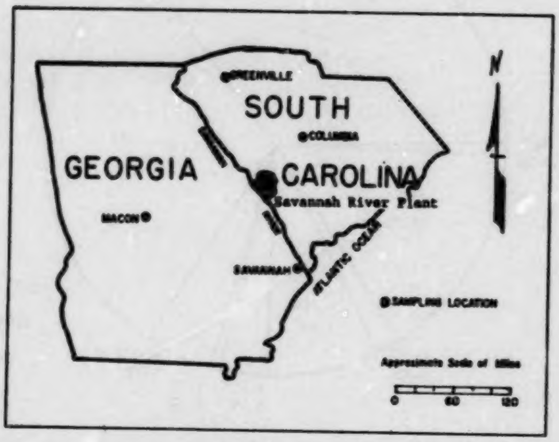

FIGURE 4.—DISTANT AIR MONITORING STATIONS, SAVANNAH RIVER PLANT

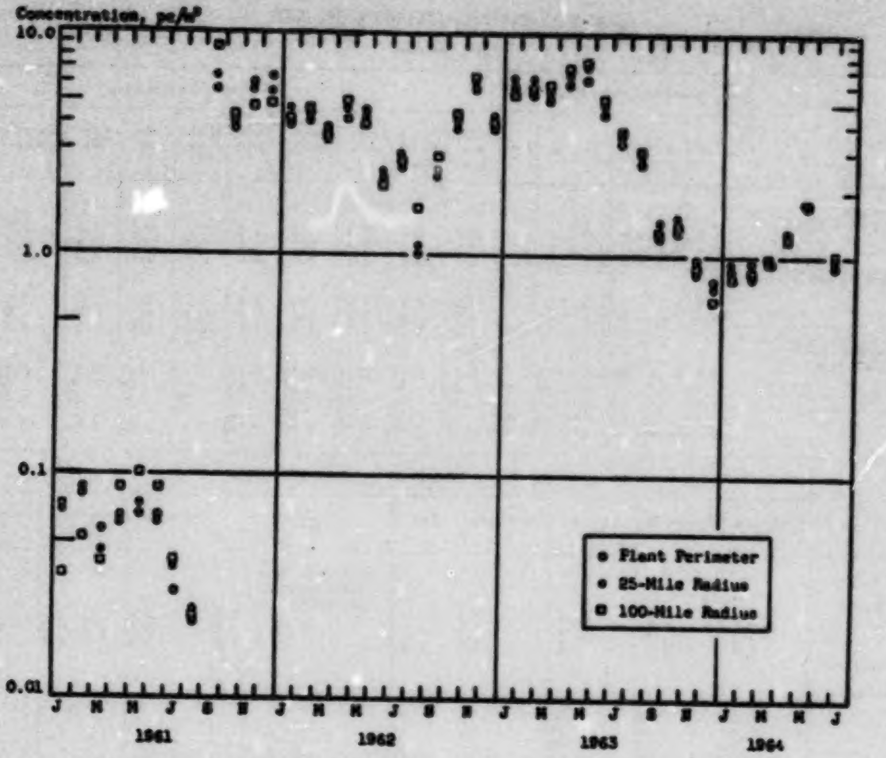

FIGURE 5.—FILTERABLE BETA RADIOACTIVITY IN AIR

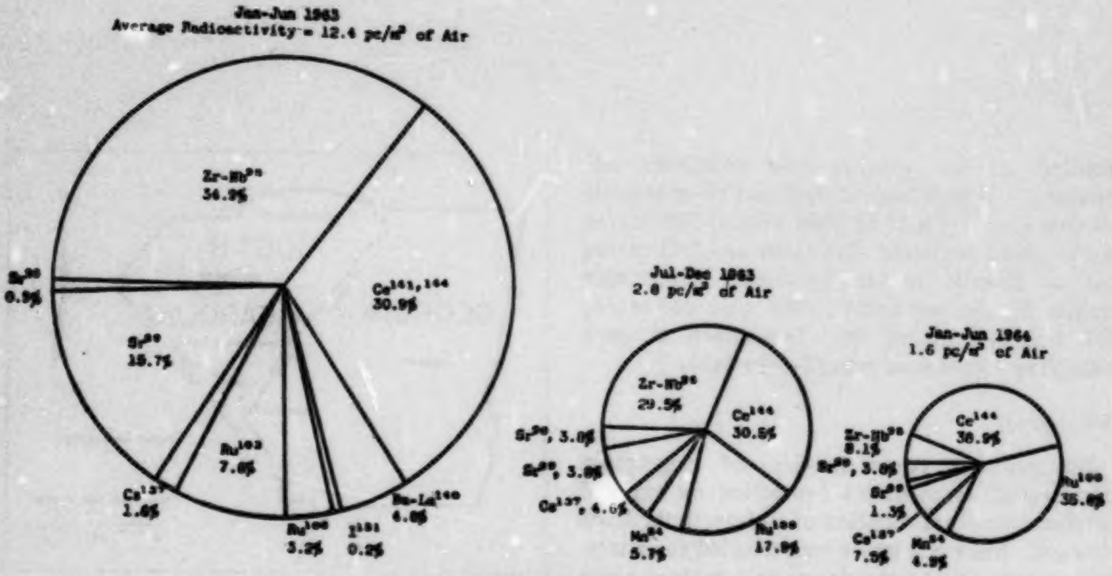

FIGURE 6.—RELATIVE ABUNDANCE OF AIRBORNE RADIONUCLIDES (WEAPONS TEST FALLOUT)

TABLE 7.—TOTAL FALLOUT DEPOSITED

(mc/sq mi)

Radionuclide	Plant-perimeter locations						25-mile-radius locations									
	A	B	C	D	E	Avg	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Avg
Alpha [a]	11.7	15.9	11.5	13.0	14.1	13.3	22.5	12.6	14.6	10.3	22.0	12.9	14.1	17.5	15.0	15.8
I^{131}	[b] *	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sr^{89}	2.5	*	*	*	*	0.5	*	4.4	4.7	1.0	4.1	*	*	*	1.3	1.7
Sr^{90}	30	35	38	36	28	30	32	16	17	20	35	37	21	30	25	25
Cs^{137}	32	27	35	38	35	28	42	31	28	25	47	40	31	32	23	34
Ce^{144}	117	133	123	189	145	135	182	84	94	88	173	139	134	144	108	138
Ru^{103}	11	13	13	15	16	14	14	7	11	7	16	14	12	11	11	11
Ru^{106}	87	101	90	94	95	90	107	84	73	64	118	92	85	101	77	88
$Zr\text{-}Nb^{95}$	25	27	28	31	29	34	44	24	27	29	45	47	31	41	41	35
Mn^{54}	25	37	30	26	28	26	30	21	20	20	30	25	23	33	38	24

[a] Multiply by 10^{12}

[b] *Less than sensitivity of analysis.

Grass samples were collected at 14 locations along the plant perimeter and at 14 other locations along a 25-mile-radius route. (These are not designated on figure 3.) Samples from each quadrant of the plant and of the surrounding area were composited for weekly analysis. Radionuclides in grass samples were from weapons test fallout. Alpha emitters averaged 0.3 pc/gram at plant perimeter and 25-mile radius locations; gamma emitters averaged 200 pc/gram and 187 pc/gram, respectively. Radiosotopic concentrations comprising gamma activity are presented in table 8. The slightly higher levels during January-June 1964 over July-December 1963 (approximately 2-fold for alpha emitters and 1.3-fold for gamma emitters) correspond to the expected seasonal variation.

TABLE 8. RADIOACTIVITY ON VEGETATION

(pc/g)

	Alpha	Cs^{137}	Ce^{144}	Ru^{103}	Ru^{106}	$Zr\text{-}Nb^{95}$	Mn^{54}
Sensitivity of analysis	0.10	0.07	0.32	0.08	0.45	0.08	0.05
Plant Perimeter (14 locations)							
Maximum	1.35	42	280	7	32	29	21
Average	0.28	18	140	3	15	12	12
25-Mile Radius (14 locations)							
Maximum	1.06	35	230	6	30	19	18
Average	0.34	15	130	3	17	11	11

Milk

Milk was sampled at four dairies within a 25-mile radius of the Plant, as shown in figure 3. Samples were taken weekly and analyzed for tritium, radioiodine, and radiocesium. Strontium-90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January-June 1964 are in table 9; radioiodine concentrations were all less than the sensitivity of the analysis.

TABLE 9. RADIOACTIVITY IN MILK

	Local dairies				Major distributors [a]
	Aiken	Allendale	North Augusta	Waynesboro, Georgia	
Tritium, pc/l [b]					
Maximum	8000	5000	7000	6000	8000
Minimum	[c] *	*	*	*	*
Average	*	4000	*	*	*
$Strontium^{90}$, pc/l [d]					
Feb 1964	25	34	30		30
June 1964	31	31	34		33
$Cesium^{137}$, pc/l [e]					
Maximum	188	195	189	219	313
Minimum	90	78	99	91	114
Average	137	110	124	133	146

[a] Milk produced in local dairies but sold by major distributors.

[b] MPC: 300,000: Sensitivity of Analysis: 3000.

[c] *Less than sensitivity of analysis.

[d] Sensitivity of Analysis: 1.0. Daily Intake Guide: 200 pc/day.

[e] Sensitivity of Analysis: 25 MPC: 2000.

Strontium-90, cesium-137, and iodine-131 in milk are attributed to fallout from nuclear weapons tests. Average concentrations measured at SRP (128 pc/l of Cs^{137}, 30 pc/l of Sr^{90}, and less than 5 pc/l of I^{131}) were consistent with those reported by the U.S. Public Health Service for most sections of the United States. The cesium concentration represented 6 percent of the MPC; daily intake guides for Sr^{90} and I^{131} are 200 pc and 100 pc, respectively. Tritium in local milk, if present, is assumed to be associated with Plant operations. The average tritum level was less than the sensitivity of the analysis which allows detection of concentrations equivalent to 1 percent of the MPC.

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Algae and Fish in Savannah River

Fish (predominantly bream) and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream, adjacent, and downstream from the plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Data from analysis of fish and algae samples are in table 10. Beta concentrations in algae adjacent to and downstream from the plant indicate some plant contribution; however, no plant effects were observed in the edible portion of fish from these locations.

Water Monitoring

The plant site is drained by five streams which empty into the Savannah River within the plant boundary (see figure 7). The city of Savannah, 130 miles downstream, gets part of its domestic water supply from the river. With this exception, the river between SRP and the Atlantic Ocean is not used for either irrigation or public drinking water.

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed monthly; concentrations of alpha activity (1.4 pc/1) and beta activity (7 pc/l) were essentially the same as those observed before plant startup in 1951. Data from analyses of all public water samples are in table 11.

River water, analyzed weekly, was sampled continuously at five locations (upstream, adjacent to, and as far as 60 miles downstream) as shown in figure 3. Concentrations of alpha and nonvolatile beta emitters in river water for the past year are summarized in table 12; average concentrations of specific radionuclides found in the river water during January-June 1964 are in table 13.

Radionuclides in river water upstream and downstream from the plant during the January-June 1964 period are shown in figure 8; the values represent the total quantities of radionuclides passing the two sampling points. Neptunium-239, iodine-131, and chrominum-51 are the primary gamma-emitting radionuclides from the plant. These nuclides, released mainly from the Reactor areas, decay rapidly (radioactive half-life less than 30 days). With the exception of strontium-89, most longer-lived materials in river water came from nuclear weapons tests. A release of strontium-89 from a Reactor area during January caused a maximum weekly strontium-89 concentration of 28 pc/liter in river water downstream from the plant (intake guide for Sr^{89} is 2,000 pc/day). This concentration was of short duration as evidenced by much lower concentrations in river water the following weeks.

Tritium (H^3), a beta emitter and the most abundant radionuclide released to the river, does not appear in figure 9, but is comparatively presented in table 8. Tritium is produced by neutron irradiation of heavy water moderator in the reactors. Chromium-51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). Tritium and chromium-51 are among the least dangerous of all radionuclides because neither concentrates in body tissues; their concentrations in river water were 3.3 percent and 0.002 percent of their respective MPC. Average concentrations of all radionuclides found in river water during January-June 1964, as shown in table 8, were only small fractions of the permissible concentrations.

TABLE 10.—RADIOACTIVITY IN SAVANNAH RIVER AQUATIC SPECIMENS

(Nonvolatile Beta Emitters, pc/g)[a]

Location	Algae (Dry Weight)				Fish (Wet Weight)						
	Samples	Max	Min	Avg	Samples	Bone			Flesh		
						Max	Min	Avg	Max	Min	Avg
Control (3 miles upstream from plant)	18	145	35	65	13	35	6	30	4	3	4
Along plant boundary	17	260	30	80	22	110	2	22	20	3	5
Highway 301 crossing (10 miles downstream from plant)	18	175	25	75	13	50	10	18	4	3	4

[a] Sensitivity of analysis: Varied due to differing sample size.

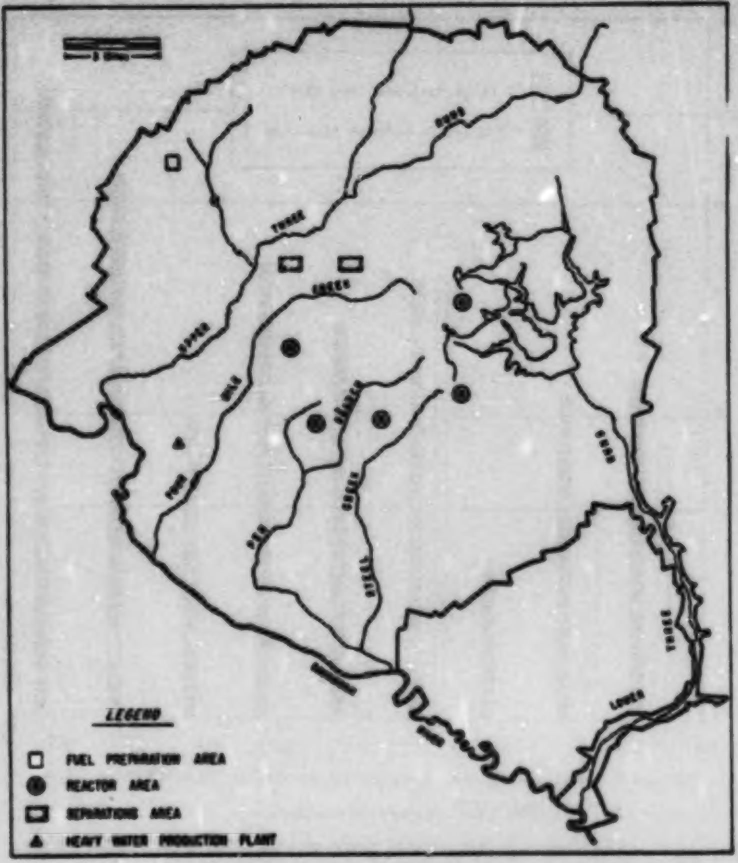
LEGEND
FUEL PREPARATION AREA
REACTOR AREA
SEPARATIONS AREA
HEAVY WATER PRODUCTION PLANT
UPPER
THREE
RUNS
CREEK
MILE
FOUR
PEN
STEEL
LOWER
THREE

FIGURE 7.—PRODUCTION AREAS AND EFFLUENT STREAMS, SAVANNAH RIVER PLANT

Environmental Gamma Radiation Levels

Monthly measurements of environmental gamma radiation were made with portable Geiger-Mueller survey instruments. January-June 1964 data in table 14 are characteristic of individual station observations during the past several years; the readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown are within the variance anticipated due to differences in normal background and in instrument response characteristics.

TABLE 11.—RADIOACTIVITY IN PUBLIC WATER SUPPLIES

	Aiken	Allendale	Augusta	Barnwell	Bath	Blackville	Clearwater	Jackson	Langley	New Ellenton	North Augusta	Sardis	Waynesboro	Williston	Avg
Alpha Emitters, pc/l [a]															
Max	3.1	0.4	*	0.2	3.3	0.6	0.3	14.0	2.4	4.3	0.2	0.4	0.2	2.1	
Min	0.5	[b] *	*	*	0.9	*	*	5.4	1.6	0.6	*	*	*	0.6	
Avg	1.8	*	*	*	2.2	0.2	*	9.6	1.9	1.6	*	*	*	1.3	1.4
Nonvolatile Beta Emitters, pc/l [c]															
Max	10	4	9	*	16	10	9	46	9	13	9	7	13	6	
Min	*	*	*	*	5	*	*	12	*	*	*	*	4	*	
Avg	7	*	6	*	7	5	7	24	6	7	3	*	6	*	7

[a] MPC: 10: Sensitivity of analysis: 0.2.
[b] *Less than sensitivity of analysis.
[c] MPC: 2000: Sensitivity of analysis: 4.0.

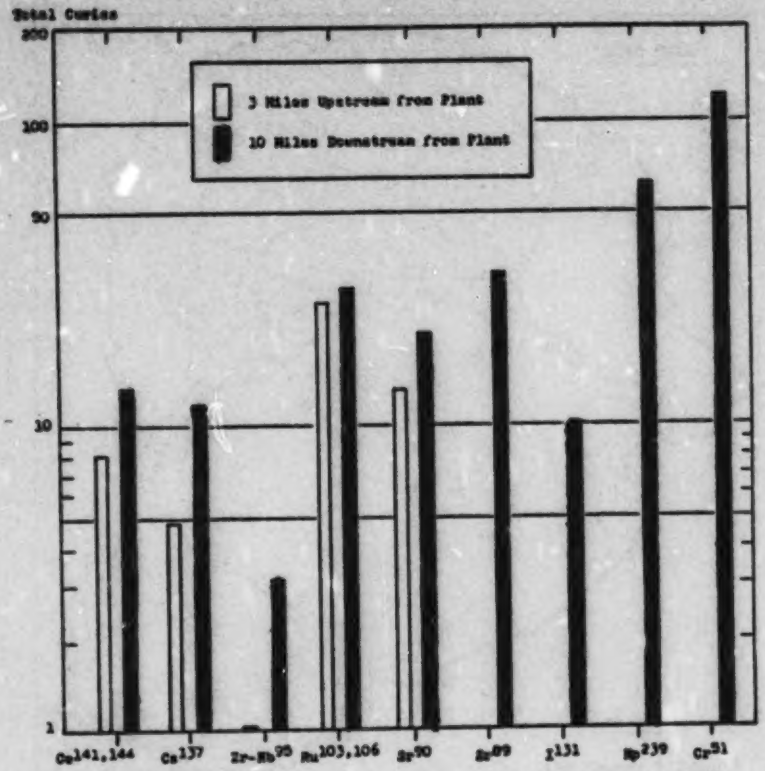

FIGURE 9.--Radionuclides in river water during January-June 1964.

Sr^{89}, I^{131}, Np^{239}, and Cr^{51} were not detectable upstream.

FIGURE 8.—RADIONUCLIDES IN RIVER WATER DURING JANUARY–JUNE 1964.(Sr^{89}, I^{131}, Np^{239}, and Cr^{51} were not detectable upstream)

TABLE 12. RADIOACTIVITY IN SAVANNAH RIVER WATER

	Control (3 miles upstream from plant)	Plant perimeter		Highway 301 (10 miles downstream from plant)	Clyo (80 miles downstream from plant)
		1	2		
Alpha Emitters, pc/l [a]					
Jan-June 1964					
Max	0.8	1.5	0.1	0.7	1.1
Min	[b] *	*	*	*	*
Avg	0.3	0.6	0.2	0.3	0.3
July-Dec 1963 Avg	*	*	*	*	*
Nonvolatile Beta Emitters, pc/l [c]					
Jan-June 1964					
Max	21	36	72	54	39
Min	7	5	8	8	9
Avg	12	20	21	21	19
July-Dec 1963 Avg	14	26	29	20	15

[a] MPC: 10; Sensitivity of Analysis: 0.2.

[b] * Less than sensitivity of analysis.

[c] MPC: 3000; Sensitivity of Analysis: 4.0.

TABLE 13. AVERAGE CONCENTRATION OF RADIONUCLIDES IN SAVANNAH RIVER WATER

(Concentration, pc/l)

Radionuclide	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at highway 301
H^3	600	1200	10,000	3.3
$Ru^{103, 106}$	3.3	6.1	6.6	0.22
$Ce^{141, 144}$	2.5	4.0	4.0	0.13
Cs^{137}	0.6	0.8	1.7	0.06
Np^{239}	0.9	[a] *	10.1	0.06
$Ba\text{-}La^{140}$	1.6	—	3.2	0.04
$Zr\text{-}Nb^{95}$	0.5	0.7	0.8	0.004
Cr^{51}	4.3	*	17.4	0.002
Sr^{89}	0.3	*	3.0	[b] **
I^{131}	0.5	*	2.3	**
Sr^{90}	0.01	1.3	2.0	**
Co^{60}	1.4	*	*	—
Zn^{65}	1.1	*	*	—
Mn^{54}	0.4	*	*	—

[a] * Less than sensitivity of analysis.

[b] ** Daily intake guides for Sr^{89}, Sr^{90}, and I^{131} are 2000 pc/day, 200 pc/day, and 100 pc/day, respectively.

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TABLE 14.—ENVIRONMENTAL GAMMA RADIATION

(mr/24 hours)

	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Avg	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Highway 301	Langley	Sardis	Waynesboro	Williston	Avg
Max	0.46	0.44	0.49	0.45	0.45		0.44	0.44	0.38	0.54	0.47	0.43	0.39	0.43	0.40	0.42	
Min	0.36	0.36	0.35	0.35	0.31		0.32	0.30	0.33	0.33	0.36	0.35	0.31	0.35	0.32	0.33	
Avg	0.41	0.40	0.42	0.40	0.39	0.40	0.39	0.36	0.36	0.40	0.41	0.36	0.37	0.38	0.36	0.38	0.38

Summary

This report, for the period January 1 through June 30, 1964, presents the results of the environmental monitoring program for the atmosphere, for vegetation and food, and for water. The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation, or was obscured by world-wide fallout from nuclear weapons testing during past years.

Beta activity in air, which shows no relationship with plant operations, was about one-eighth of that for the same period of 1963. Radionuclides in milk were at the same levels as those reported for most sections of the United States by the U. S. Public Health Service. The concentration of radioactive materials in river algae indicated some slight contribution from the plant. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. In no instance was the concentration of radionuclides in river water in excess of 3.3 percent of the Maximum Permissible Concentration.

REFERENCES

(*1*) U. S. ATOMIC ENERGY COMMISSION. Rules and regulations, standards for protection against radiation. Federal Register. Title 10, Part 20, Appendix B, Table 2. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

(*2*) NATIONAL COMMITTEE ON RADIATION PROTECTION. Maximum permissible body burdens and permissible concentrating of radionuclides in air and water for occupational exposure. Natl. Bureau of Standards Handbook 69: (June 1959), Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2 (September 1961) Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

REPORTED NUCLEAR DETONATIONS, JANUARY 1965

During January 1965, the Atomic Energy Commission announced two underground nuclear tests, one of which was a U.S. test, the other being a Soviet test detected through seismic signals. The U.S. test conducted on January 14 at the Nevada Test Site was in the low yield range. The Soviet test detected on January 15 was tracted to the Semipalatinsk area and was in the intermediate yield range. Some evidence of venting connected with the Soviet test has been found by the U.S. detection system, but radioactivity identified with the event was not expected to produce measureable exposures to persons. (Low yield range is defined as less than 20 kilotons and intermediate yield ranges from 200 kilotons to 1 megaton.)

RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis for alerting systems to determine when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also compared in beta concentration isograms.

1. Radiation Surveillance Network
November 1964

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the Division of Radiological Health, PHS, which regularly gathers samples from 73 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators telephone any daily field estimates over 10 pc/m^3 to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. Lower field estimates are reported to the Center by the laboratory at Rockville, Maryland, which receives a daily written report together with the air filter submitted by each station operator. The filters are counted at the laboratory to confirm field estimates. Analyses for specific radionuclides may also be made if gross beta activity concentrations are high. All field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}-Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and again

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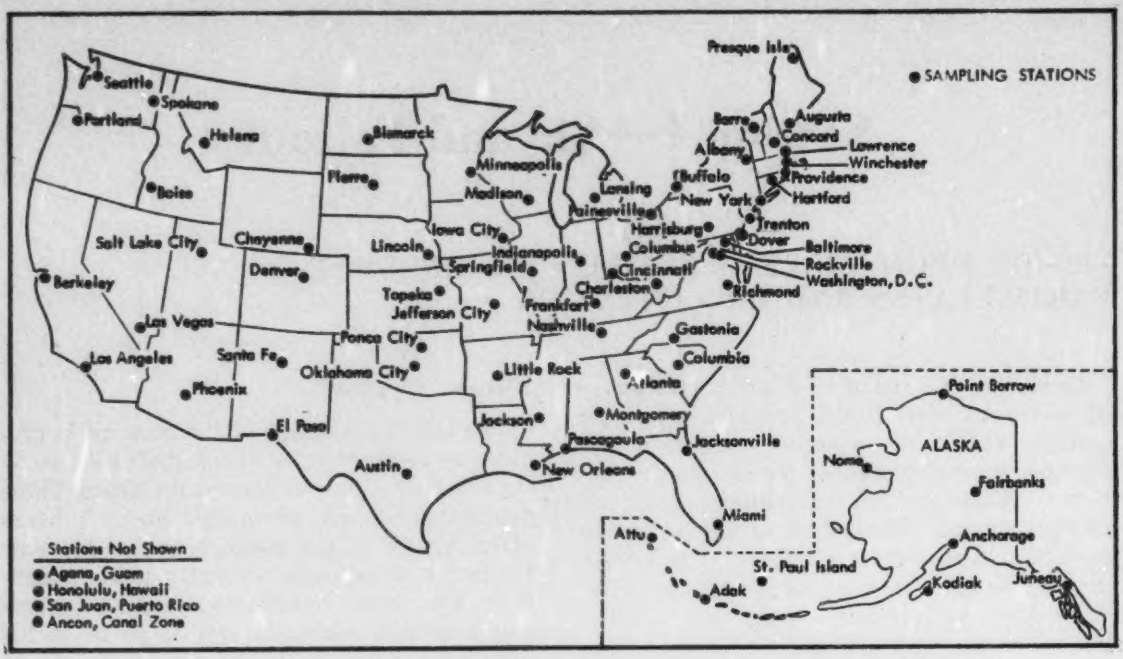
● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Buffalo
Painesville
New York
Presque Isle
Augusta
Barre
Concord
Albany
Lawrence
Winchester
Providence
Hartford
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
Harrisburg
Columbus
Cincinnati
Charleston
Frankfort
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jacksonville
Miami
Pascagoula
New Orleans
Jackson
Little Rock
Salt Lake City
Cheyenne
Denver
Lincoln
Iowa City
Indianapolis
Springfield
Topeka
Jefferson City
Berkeley
Las Vegas
Los Angeles
Santa Fe
Phoenix
Ponca City
Oklahoma City
El Paso
Austin
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING LOCATIONS

7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*).

Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

Precipitation measurements

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D=\frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C}=\frac{\Sigma D}{\Sigma P}\times 1000$$

The November 1964 average concentrations and total depositions are given in table 1.

---

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, NOVEMBER 1964

Station location		Air surveillance					Precipitation measurement	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Total Depth (mm)[b]	Total deposition (nc/m²)[b]
			Maximum	Minimum	Average[a]			
Ala:	Montgomery	30	2.96	<0.10	0.72	Aug 64	89.6	18.8
Alaska:	Adak	25	0.53	<0.10	0.22	Nov 64		
	Anchorage	28	0.30	<0.10	0.17	Jul 64	69.3	18.1
	Attu	28	0.34	<0.10	0.15	Dec 64		
	Fairbanks	19	0.38	<0.10	<0.14	Aug 64	23.8	6.0
	Juneau	14	0.19	<0.10	<0.14	Sep 64	107.1	40.2
	Kodiak	10	0.59	<0.10	<0.25	Oct 64		
	Nome	15	0.27	<0.10	<0.16	Feb 65		
	Point Barrow	27	0.51	<0.10	0.14	Jan 65		
	St. Paul Island	28	0.39	<0.10	<0.16	Mar 65		
Ariz:	Phoenix	30	1.13	0.24	0.64	Sep 64		
Ark:	Little Rock	26	2.27	<0.10	0.72	Sep 64	105.4	21.1
Calif:	Berkeley	29	0.72	<0.10	0.28	Oct 64	101.7	22.7
	Los Angeles	29	1.31	<0.10	0.48	Feb 65	43.4	8.7
Canal Zone:	Ancon	11	0.72	<0.10	<0.15	Nov 64		
Colo:	Denver	26	1.51	<0.10	0.44	Oct 64	13.9	4.9
Conn:	Hartford	29	0.90	0.14	0.46	Oct 64	54.3	13.5
Del:	Dover	17	1.42	0.26	0.60	Aug 64		
D. C:	Washington	27	1.52	0.11	0.68	Feb 65	17.3	3.5
Fla:	Jacksonville	29	1.73	<0.10	0.59	Sep 64	98.4	25.2
	Miami	29	1.18	<0.10	0.52	Oct 64	35.7	8.7
Ga:	Atlanta	[b]				Jul 64	11.8	9.8
Guam:	Agana	30	1.83	<0.10	<0.22	Apr 64		
Hawaii:	Honolulu	29	0.33	<0.10	<0.15	Dec 64	69.2	16.6
Idaho:	Boise	29	1.01	<0.10	0.36	Dec 64	31.5	11.7
Ill:	Springfield	27	2.19	<0.10	0.63	Feb 65		
Ind:	Indianapolis	13	2.59	0.17	0.98	Jul 64	86.1	17.3
Iowa:	Iowa City	26	1.44	0.13	0.47	Nov 64	33.8	17.3
Kans:	Topeka	26	1.58	<0.10	0.37	Jul 64	101.9	31.6
Ky:	Frankfort	27	2.69	0.15	0.86	Feb 65	47.3	13.2
La:	New Orleans	29	1.82	<0.10	0.46	Feb 65	63.7	16.9
Maine:	Augusta	30	1.43	<0.10	0.39	Mar 64	109.6	27.0
	Presque Isle	15	0.51	<0.10	0.24	Nov 64		
Md:	Baltimore	28	1.12	0.13	0.51	Oct 64	20.0	4.0
	Rockville	14	2.34	0.23	0.87	Jan 65		
Mass:	Lawrence	29	1.44	0.20	0.60	Aug 64	47.6	22.3
	Winchester	28	1.44	0.24	0.62	Dec 64	33.0	12.4
Mich:	Lansing	30	3.12	0.21	0.79	Jan 65	15.6	9.0
Minn:	Minneapolis	[illegible]	0.71	<0.10	0.24	Mar 64	31.9	10.3
Miss:	Jackson	25	2.22	<0.11	0.73	Mar 65	152.6	30.6
	Pascagoula	15	2.61	0.13	0.78	Dec 64		
Mo:	Jefferson City	28	1.99	<0.10	0.53	July 64	82.9	16.8
Mont:	Helena	30	1.01	0.12	0.40	Nov 64	14.0	3.2
Nebr:	Lincoln	13	1.26	<0.10	0.50	Mar 65		
Nev:	Las Vegas	24	0.80	<0.10	0.30	Aug 64	7.3	1.5
N. H:	Concord	18	0.90	<0.10	0.47	Feb 65		
N. J:	Trenton	30	1.04	<0.10	0.44	Mar 65	11.2	3.3
N. Mex:	Santa Fe	22	1.20	<0.10	0.41	Nov 64	11.2	2.5
N. Y:	Albany	25	1.38	0.12	0.49	Jul 64	36.9	15.4
	Buffalo	20	1.50	0.14	0.56	Nov 64		
	New York	20	1.16	<0.10	0.81	Dec 64		
N. C:	Gastonia	29	2.28	<0.10	0.82	Nov 64	57.3	14.2
N. Dak:	Bismarck	28	0.82	<0.10	0.29	Jan 65	3.2	1.7
Ohio:	Cincinnati	19	2.40	0.16	0.68	Aug 64		
	Columbus	29	2.13	0.21	0.82	Mar 65	43.1	13.0
	Painesville	30	2.43	0.22	0.88	Oct 64	14.6	6.3
Okla:	Oklahoma City	29	3.26	<0.10	0.55	Jan 65	102.8	33.9
	Ponca City	29	1.60	<0.10	0.31	Oct 64	155.7	43.1
Ore:	Portland	27	1.09	<0.10	0.38	Mar 65	120.3	41.5
Pa:	Harrisburg	30	1.32	0.11	0.47	Jul 64	9.8	3.5
P. R:	San Juan	28	0.43	<0.10	<0.19	Mar 65	75.9	15.2
R. I:	Providence	28	1.08	0.16	0.45	Jan 65	67.1	16.5
S. C:	Columbia	23	2.06	<0.10	0.69	Dec 64	35.5	7.2
S. Dak:	Pierre	28	1.10	<0.10	0.35	Sep 64		
Tenn:	Nashville	30	3.04	<0.10	0.93	Jan 65	105.3	34.0
Tex:	Austin	27	3.65	<0.10	0.62	Aug 64	72.0	29.5
	El Paso	26	1.33	0.11	0.61	Jan 65		
Utah:	Salt Lake City	27	1.28	0.13	0.53	Feb 65	40.4	15.2
Vt:	Barre	30	1.21	<0.10	0.50	Sep 64	52.7	19.6
Va:	Richmond	30	0.97	<0.10	0.48	Sep 64	50.4	10.6
Wash:	Seattle	29	0.66	<0.10	<0.18	Jul 64	201.6	98.5
	Spokane	30	0.67	<0.10	0.22	New		
W. Va:	Charleston	29	2.11	<0.10	0.82	Dec 64	67.4	14.4
Wis:	Madison	30	2.91	0.14	0.63	Sep 64	53.7	27.7
Wyo:	Cheyenne	28	1.14	<0.10	0.39	Aug 64		
Network summary		1,880	3.65	<0.10	[c] 0.48		[c] 53.8	[c] 17.9

---

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign appears before the average.

[b] Blank indicates no report received.

[c] Arithmetic average of the station averages.

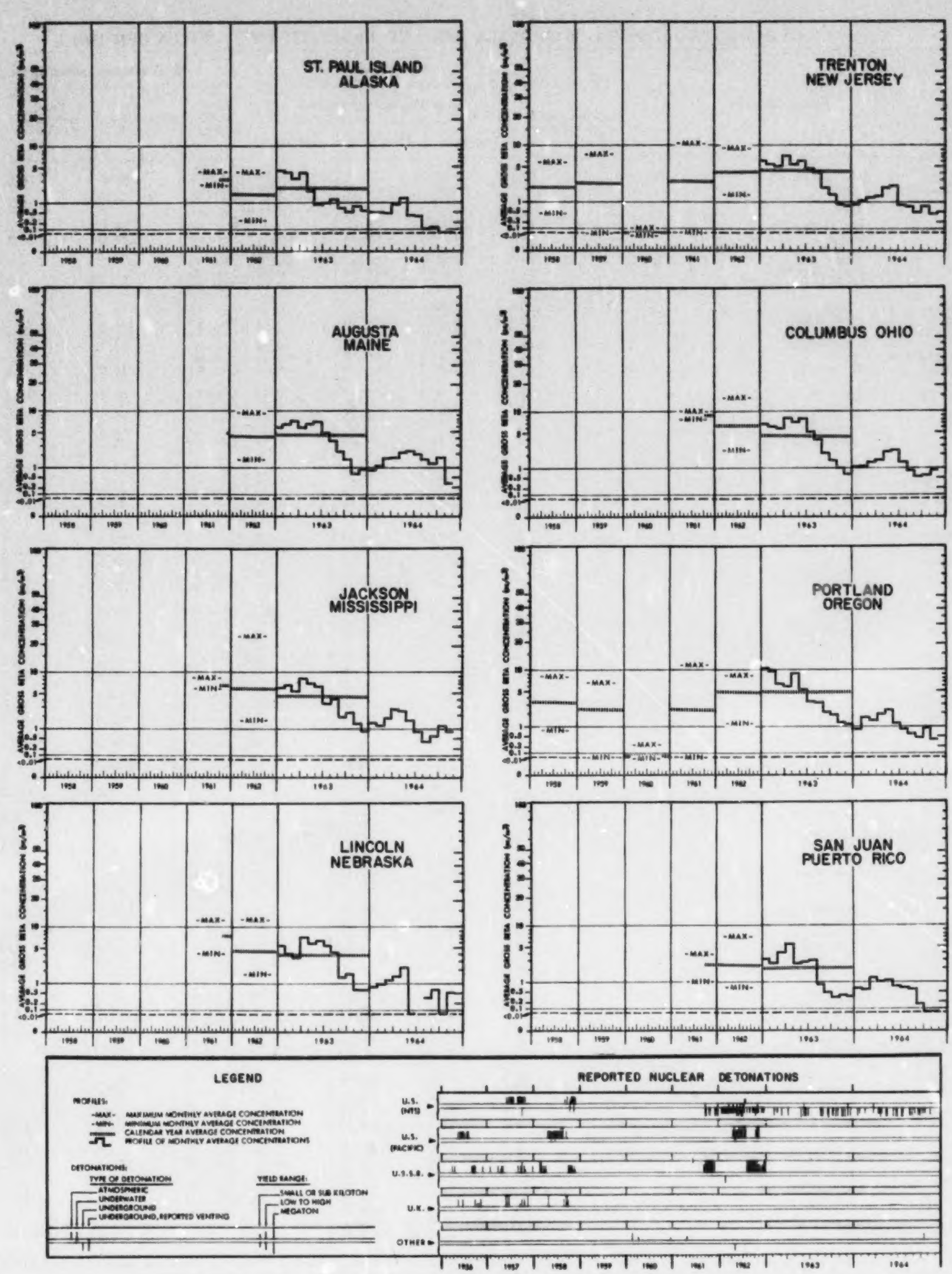

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–NOVEMBER 1964

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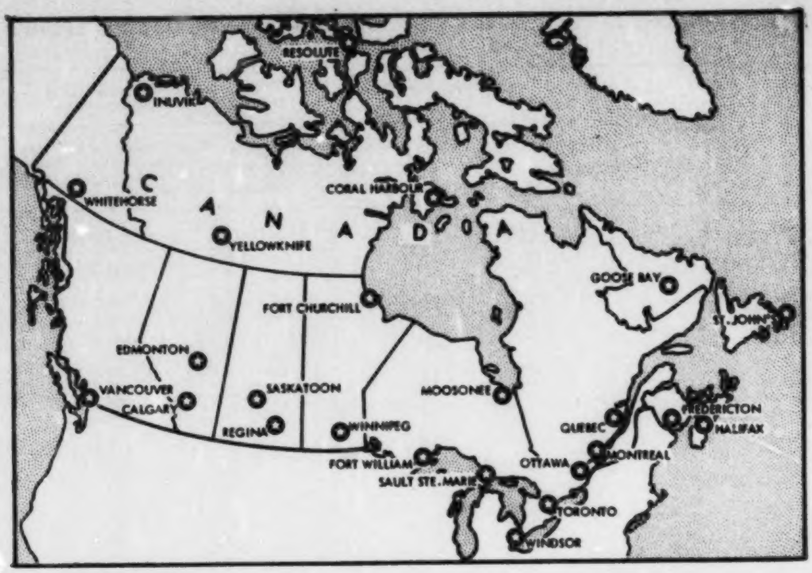

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

2. Canadian Air Monitoring Program [2] November 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3-7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for November 1964 are given in table 2 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 5).

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for November 1964 samples are given in table 2. Radionuclide analyses are reported quarterly in *RHD*.

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[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Program*, Vol. 2, No. 12, 11-24 (December 1964), Canadian Department of National Health and Welfare, Ottawa, Canada.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, NOVEMBER 1964

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	30	1.7	0.1	0.4	201	4.2
Coral Harbour	29	0.3	0.1	0.2	210	5.3
Edmonton	30	1.7	0.1	0.4	102	6.0
Ft. Churchill	30	0.3	0.1	0.2	120	3.2
Ft. William	30	1.4	0.1	0.3	311	11.1
Fredericton	30	0.6	0.1	0.2	85	6.3
Goose Bay	30	0.5	0.1	0.2	57	3.7
Halifax	29	0.3	0.0	0.1	153	13.5
Inuvik	30	0.4	0.1	0.2	94	1.6
Montreal	30	0.8	0.1	0.3	142	10.5
Moosonee	29	0.5	0.0	0.2	90	7.8
Ottawa	30	1.0	0.1	0.3	103	8.4
Quebec	30	1.1	0.1	0.3	90	11.9
Regina	30	1.1	0.1	0.3	216	2.6
Resolute	30	0.4	0.1	0.2	128	9.5
St. John's, Nfld	28	0.4	0.1	0.2	44	7.8
Saskatoon	30	1.4	0.1	0.3	501	1.9
Sault Ste. Marie	30	1.5	0.1	0.4	100	13.0
Toronto	30	0.6	0.1	0.3	80	3.9
Vancouver	30	0.5	0.1	0.2	56	8.7
Whitehorse	30	0.3	0.1	0.2	47	0.6
Windsor	30	1.8	0.1	0.5	323	7.0
Winnipeg	30	1.4	0.1	0.4	245	3.9
Yellowknife	30	0.5	0.1	0.2	87	1.5
Network summary		0.9	0.1	0.3	152	6.4

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

3. Mexican Air Monitoring Program November 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8-12*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of

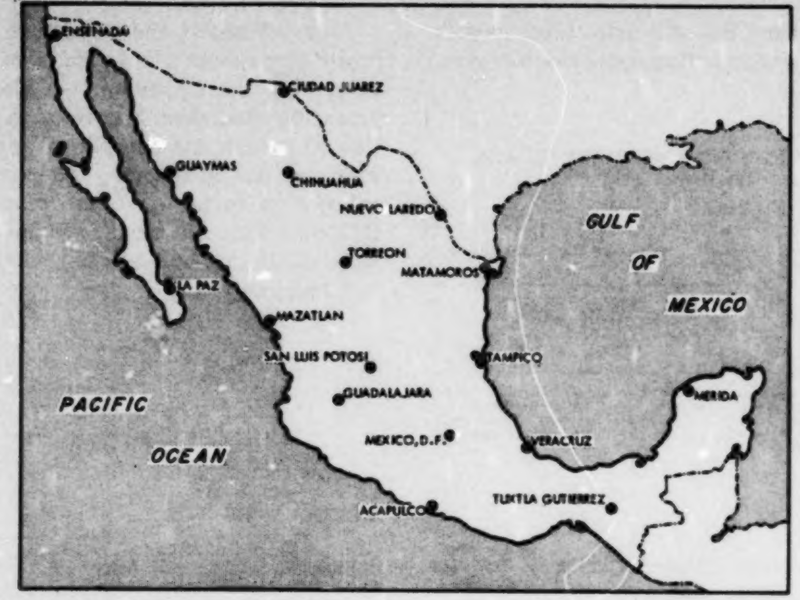

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during November 1964 are presented in table 3. The data are also represented in the beta activity isogram map of North America, figure 5.

TABLE 3.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, NOVEMBER 1964

Station	Number of Samples	Gross beta activity (pc/m^3)		
		Maximum	Minimum	Average
Acapulco	2	—	—	0.2
Ciudad Juárez	23	1.0	0.1	0.4
Chihuahua	15	1.1	0.1	0.3
Ensenada	10	2.1	0.2	0.7
Guadalajara	10	0.1	0.0	0.1
Guaymas	8	0.6	0.1	0.3
La Paz	15	0.9	0.2	0.5
Matamoros	16	0.9	<0.1	0.3
Mazatlán	9	0.8	<0.1	0.4
Mérida	15	1.9	<0.1	0.4
México, D.F.	16	0.4	<0.1	0.1
Nuevo Laredo	13	1.5	0.1	0.4
San Luis Potosí	13	1.5	<0.1	0.4
Tampico	13	1.4	<0.1	0.3
Torreón	11	1.1	0.1	0.4
Tuxtla Gutiérrez [a]				
Veracruz	13	3.5	<0.1	0.7

[a] Blank indicates station temporarily shut down.

4. Pan American Air Sampling Program November 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

The November 1964 air monitoring results from the four participating countries are given in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN AIR, NOVEMBER 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	19	0.30	<0.10	<0.12
Caracas, Venezuela	21	0.13	<0.10	<0.10
Lima, Peru[b]	—	—	—	—
Santiago, Chile	29	0.26	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

[b] No report received.

5. Gross Beta Activity in Air, North America November 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*13*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*14*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

Figure 5 shows the November 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network, the Pan American Air Sampling Program, and the Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN and Pan American and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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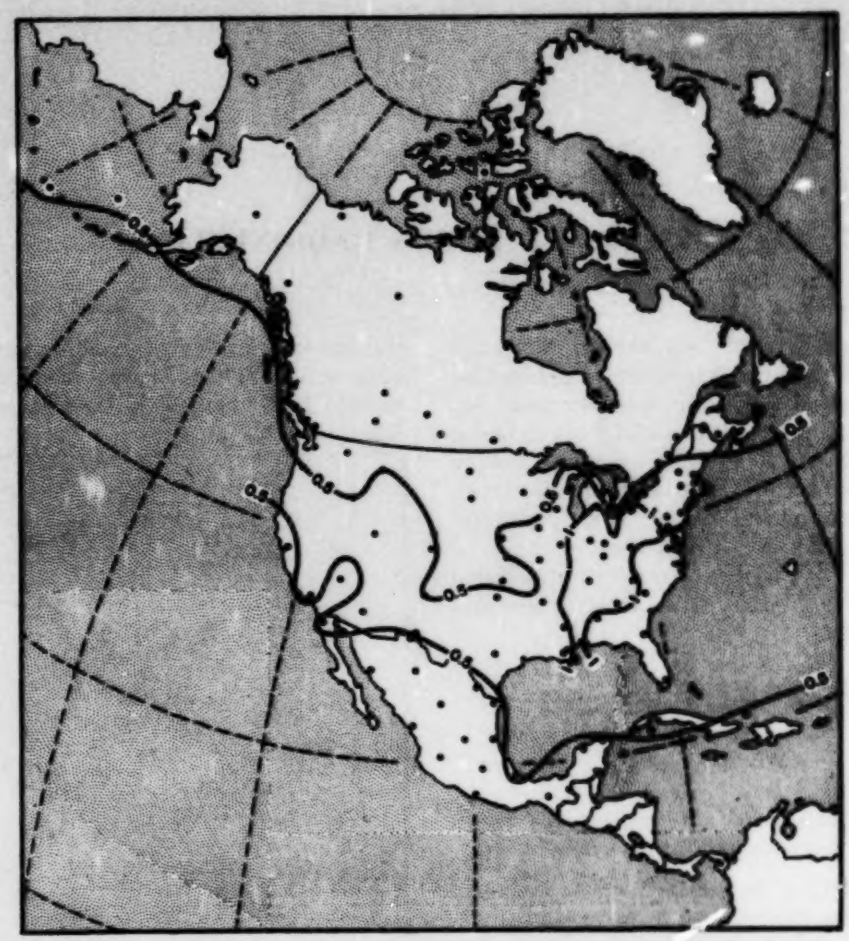

FIGURE 5.—ISOGRAM OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR, NORTH AMERICA, NOVEMBER 1964

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MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section the word "fallout" refers to the deposition of radioactive materials on the earth's surface, normally expressed in terms of the activity of selected radionuclides deposited on a unit area during a given period of time. Unless otherwise stated, fallout measurements include both precipitation and dry fallout (settled dust).

Reports of fallout measurements at selected stations in North and South America are presented below.

1. Fallout in the United States and Other Areas,[1] April-June 1964

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from 38 of the U. S. stations and 24 other selected points in the Western Hemisphere (see figure 1) covering the period from April through June 1964 are summarized below. All the stations of the 80th Meridian Network except Washington, D. C. are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of one month in stainless steel pots with exposed areas of $0.076 m^2$. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

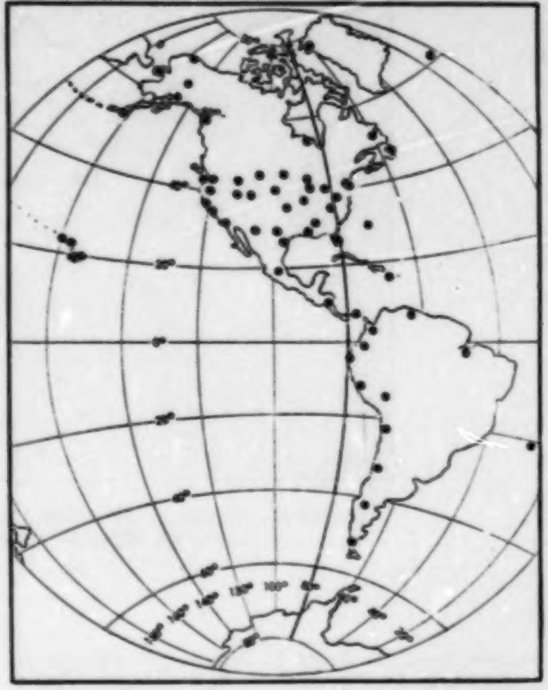

FIGURE 1.—HASL FALLOUT SAMPLING STATIONS

The second method involves the use of a polyethylene funnel, with exposed area of $0.07 m^2$, attached to an ion exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

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[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL-155*, Health and Safety Laboratory, AEC, New York, New York 10014.

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT IN THE UNITED STATES, HASL, APRIL–JUNE 1964

[Deposition in mc/mi²]

Sampling location and type of collection			April	May	June
Ala:	Birmingham	(pot)	0.39	1.06	2.08
Alaska:	Anchorage	(col)	[a] 0.47	0.74	0.57
	Barrow [b]	(col)	—	—	—
	Cold Bay	(col)	0.87	1.15	1.02
	Fairbanks	(col)	0.22	0.44	1.27
	Juneau	(col)	(c)	2.88	2.70
	Nome	(col)	(c)	0.28	0.03
Calif:	W. Los Angeles	(pot)	0.04	0.08	(b)
	Palo Alto [b]	(pot)	—	—	—
	Palo Alto	(col)	0.07	0.22	0.12
	San Francisco	(col)	0.12	0.21	0.17
Colo:	Denver	(col)	0.22	1.47	4.58
Fla:	Coral Gables	(pot)	(c)	3.04	2.15
	Miami	(col)	0.90	7.04	2.00
Hawaii:	Hilo	(col)	1.86	6.84	0.35
	Lihue	(col)	1.73	0.84	4.40
	Mauna Loa	(col)	0.22	0.23	0.01
	Oahu	(pot)	1.19	1.19	0.69
Ill:	Argonne	(pot)	2.74	1.20	3.22
La:	New Orleans	(col)	1.87	0.47	0.94
Minn:	International Falls	(col)	1.84	3.05	0.49
Mo:	Columbia	(col)	1.68	3.74	1.87
Mont:	Helena	(col)	0.46	1.43	2.76
N.J.	Westwood	(pot)	2.58	0.86	2.29
	Westwood	(col)	(c)	0.80	1.84
N.Y.	New York	(pot)	4.74	0.52	2.55
N.D.	Williston	(col)	0.29	0.72	2.94
Ohio:	Wooster	(pot)	3.14	3.03	3.04
Okla:	Tulsa	(pot)	[d] 1.30	[d] 1.60	(b)
Ore:	Medford	(col)	0.19	0.35	1.04
S.C.:	Columbia	(col)	0.74	1.14	(b)
S. Dak:	Vermillion	(pot)	4.22	2.84	4.58
Texas:	Dallas	(col)	1.57	2.01	0.61
	El Paso	(col)	0.34	0.05	0.19
	Houston	(col)	0.38	0.54	0.49
Utah:	Salt Lake City	(pot)	5.70	2.31	8.58
Va:	Sterling (U.S. Weather Bureau Station)	(col)	1.89	0.71	0.21
Wash:	Seattle	(pot)	1.47	1.23	2.58
	Tatoosh Island	(col)	0.15	0.91	1.59
Wis:	Green Bay	(col)	1.42	1.73	(b)

[a] Lower limit of reported data.
[b] No data reported.
[c] No data available.
[d] Proportioned from originally consolidated data.

Strontium-90

All of the HASL fallout samples—both pot and column—were assayed for strontium-90. The strontium-90 data are given in tables 1 and 2 for selected stations. Where duplicate samples were collected, the average values are given.

Other radionuclides

Laboratories at Palo Alto, California; Westwood, New Jersey; Oklahoma City, Oklahoma; Chattanooga, Tennessee; Seattle, Washington; and Appleton, Wisconsin have analyzed monthly pot samples for various radionuclides. The monthly deposition rates for Sr^{90}, Sr^{89}, Ce^{144}, Cs^{137}, Zr^{95}, Mn^{54} and precipitation depth are presented in tables 1-3.

2. Fallout Measurements in Canada
July-September 1964

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling network described earlier in this issue represent total fallout (wet and dry), since they are collected in deep pots lined with polyethylene. The radiochemical analyses of these samples for July through September 1964 are given in table 4.

TABLE 2.—MONTHLY STRONTIUM-90 FALLOUT IN NORTH AND SOUTH AMERICA, HASL, APRIL–JUNE 1964

[Deposition in nc/m²]

Station and type of collection		April	May	June
Bermuda:	(Kindley AFB)(col)	0.42	0.79	1.16
Bolivia:	La Paz(col)	0.03	0.03	0.01
Brazil:	Belem(col)	0.18	0.36	0.09
	Trinidade Island(col)	0.01	0.06	0.59
Canada:	Ontario, Moosonee [a](col)	1.06	2.54	3.13
	Ernest Harmon AB(col)	1.27	1.67	2.23
	Goose AB [b](col)	—	—	—
Chile:	Antofagasta [a](col)	0.02	0.02	(b)
	Puerto Montt [a](col)	0.10	0.36	(b)
	Punta Arenas [a](col)	0.03	0.10	(b)
	Santiago [a](pot)	0.02	(b)	(b)
	Santiago(col)	0.06	(c)	(c)
Columbia:	Bogota(pot)	[d] 0.10	0.03	0.07
Costa Rica:	Turrialba(col)	0.11	0.37	0.25
Equador:	Quayaquil [a](col)	0.06	0.08	(b)
	Quito(col)	(c)	0.03	0.02
Greenland:	Thule [a](col)	0.13	0.07	0.19
Iceland:	Keflavik(col)	0.42	0.58	2.39
Mexico:	Mexico City [b](col)	—	—	—
Canal Zone	(col)	0.24	0.34	0.04
Peru:	Lima [a](col)	0.01	0.03	0.02
	Lima(col)	0.02	0.05	(b)
Puerto Rico:	San Juan(col)	1.23	0.76	0.87
Venezuela:	Caracas(col)	0.17	0.17	(b)

[a] 80th Meridian Network Station.
[b] No data reported.
[c] No data available.
[d] Proportioned from originally consolidated data.

TABLE 3.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPLES AT 6 U.S. SITES, HASL, APRIL–JUNE 1964

Sampling location by State and city	Fission Product and "Tracer" Radionuclides in Monthly Collections [Deposition in nc/m²]																				
	Precipitation (mm)			Strontium-89			Strontium-90			Cerium-144			Cesium-137			Zirconium-95			Manganese-54		
	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun
California, Palo Alto	1.02	13.21	13.72	<0.01	<0.06	<0.02	0.05	0.22	0.12	2.20	4.21	2.04	0.15	0.43	0.14	0.05	0.09	0.08	0.08	0.15	0.07
New Jersey, Westwood	155.96	26.67	62.48	[a]	[a]	[a]	2.58	0.86	2.39	29.36	8.53	24.01	4.48	1.36	4.13	1.87	0.34	0.52	2.53	1.0	1.90
Oklahoma, Okla. City	53.34	95.0	17.27	<0.67	<0.10	<0.05	1.33	2.54	0.73	15.13	31.11	9.65	2.14	4.17	1.01	0.21	0.60	0.10	1.07	2.00	0.59
Tennessee, Chattanooga	249.68	125.48	84.33	[a]	[a]	[a]	4.40	2.11	1.43	64.85	26.36	12.97	9.65	3.28	2.52	3.34	1.04	0.49	4.01	2.12	1.26
Washington, Seattle	33.78	35.31	77.98	<0.03	0.04	<0.04	1.54	1.87	1.15	14.71	12.27	8.57	1.90	2.40	1.73	0.77	0.51	0.32	1.49	1.67	1.08
Wisconsin, Appleton	66.04	135.13	38.35	[a]	[a]	[a]	1.35	2.46	0.77	16.79	28.99	7.37	2.37	4.17	1.31	0.96	0.97	0.26	1.20	2.85	0.73

[a] No sample received

TABLE 4.—ANALYSIS OF FALLOUT FOR SPECIFIC RADIONUCLIDES, JULY–SEPTEMBER 1964

[Deposition in nc/m²]

Station	July		August		September	
	Sr^{90}	Cs^{137}	Sr^{90}	Cs^{137}	Sr^{90}	Cs^{137}
Calgary	1.22	2.10	0.39	0.76	0.43	0.64
Coral Harbour	0.53	1.10	0.76	0.97	0.31	0.56
Edmonton	1.15	2.46	1.10	1.83	0.51	0.91
Ft. Churchill	1.31	3.07	0.63	1.15	0.43	0.76
Ft. William	0.62	1.14	1.18	1.93	0.57	1.16
Fredericton	1.15	1.91	0.99	1.61	0.44	0.57
Goose Bay	2.96	3.92	0.98	1.51	0.53	0.71
Halifax	1.56	2.38	0.89	1.53	0.47	0.83
Inuvik	1.97	3.16	0.26	0.49	0.10	0.24
Montreal	1.86	3.10	0.77	1.21	0.19	0.32
Moosonee	0.95	1.49	1.41	2.27	[illegible]	0.82
Ottawa	1.99	3.22	0.46	0.85	[illegible]	0.51
Quebec	1.86	2.74	1.22	2.33	0.34	0.46
Regina	2.16	5.71	0.91	1.32	[illegible]	0.58
Resolute	0.24	2.36	0.50	7.08	[a] —	[illegible]
St. John's, Nfld	0.72	1.57	1.46	2.19	[a] —	1.06
Saskatoon	0.74	1.93	1.15	1.67	0.78	1.23
Sault Ste. Marie	0.53	1.51	0.97	1.47	0.60	1.03
Toronto	1.87	3.22	0.94	1.74	0.31	0.33
Vancouver	1.90	2.26	0.66	1.15	0.90	1.19
Whitehorse	0.43	0.98	0.71	0.94	0.23	0.43
Windsor	1.75	2.46	1.11	1.76	0.53	0.73
Winnipeg	0.67	1.81	1.07	1.78	0.29	0.51
Yellowknife	0.25	0.52	1.35	0.58	0.57	0.67

[a] No analysis.

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, November 1964

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after monthly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

Analytical procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes per gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 1 gives the 95 percent confidence limits between which the true concentrations of the selected radionuclides might be expected in the analyses. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	± 5	50 or greater	±10
Strontium-90	0 to 20	± 2	20 or greater	±10

[a] Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations[2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for November 1964 (November 1-28). Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine-131 and barium-140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations *versus* radionuclide concentrations in milk, tables 3 and 4 have been prepared from the monthly averages shown in table 2, and November 1963 data has been included for comparison.

The average monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. The data regarding reported nuclear detonations given in this figure are presented for information only. The underground nuclear detonations during 1963 and 1964 are not intended to imply a cause and effect relationship with the rising strontium levels during this period.

Each graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

[2] The conversion factor is 1.18×10^{-9} g K/pc K^{40}.

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, NOVEMBER 1964

Sampling locations		Calcium (g/liter)		Strontium-89 (pc/liter)		Strontium-90 (pc/liter)		Cesium-137 (pc/liter)		Iodine-131 (pc/liter)		Barium-140 (pc/liter)	
		Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month
Ala:	Montgomery	1.17	1.20	<5	<5	21	20	65	60	0	0	0	0
Alaska:	Palmer	1.17	1.27	<5	<5	16	19	105	80	0	0	0	0
Ariz:	Phoenix	1.15	1.20	<5	<5	3	4	25	20	0	0	0	0
Ark:	Little Rock	1.15	1.18	<5	<5	38	33	80	60	0	0	0	0
Calif:	Sacramento	1.26	1.31	<5	<5	6	6	30	30	0	0	0	0
	San Francisco	1.22	1.23	<5	<5	7	4	35	35	0	0	0	0
C. Z:	Cristobal	1.11	1.14	<5	<5	5	5	50	50	0	0	0	0
Colo:	Denver	1.25	1.24	<5	<5	20	16	100	60	0	0	0	0
Conn:	Hartford	1.10	1.16	<5	<5	19	14	110	90	0	0	0	0
Del:	Wilmington	1.15	1.19	<5	<5	20	16	85	70	0	10	0	0
D. C:	Washington	1.11	1.14	<5	<5	19	17	65	40	0	0	0	0
Fla:	Tampa	1.19	1.19	<5	<5	17	14	255	210	0	0	0	0
Ga:	Atlanta	1.17	1.19	<5	<5	28	25	105	90	0	0	0	0
Hawaii:	Honolulu	1.19	1.20	<5	5	11	15	70	70	0	0	0	0
Idaho:	Idaho Falls	1.24	1.24	<5	<5	25	21	110	85	0	0	0	0
Ill:	Chicago	1.14	1.20	<5	<5	19	16	85	70	0	0	0	0
Ind:	Indianapolis	1.15	1.22	<5	<5	18	15	70	60	0	10	0	0
Iowa:	Des Moines	1.21	1.23	<5	<5	22	23	70	50	0	0	0	0
Kans:	Wichita	1.17	1.27	<5	<5	18	19	50	30	0	0	0	0
Ky:	Louisville	1.13	1.19	<5	<5	27	24	50	45	0	0	0	0
La:	New Orleans	1.19	1.23	<5	15	48	40	115	70	0	0	0	0
Maine:	Portland	1.14	1.23	<5	<5	29	26	175	155	0	10	0	0
Md:	Baltimore	1.13	1.17	<5	<5	21	19	70	50	0	0	0	0
Mass:	Boston	1.13	1.17	<5	<5	31	23	180	130	0	0	0	0
Mich:	Detroit	1.14	1.19	<5	<5	16	16	90	75	0	10	0	0
	Grand Rapids	1.15	1.23	<5	<5	19	20	100	90	0	10	0	0
Minn:	Minneapolis	1.21	1.24	<5	5	27	23	115	75	0	0	0	0
Miss:	Jackson	1.21	1.23	<5	5	37	30	85	60	0	0	0	0
Mo:	Kansas City	1.19	1.22	<5	<5	26	21	55	40	0	0	0	0
	St. Louis	1.20	1.24	<5	<5	21	18	55	40	0	0	0	0
Mont:	Helena	1.20	1.26	<5	<5	20	15	115	85	0	0	0	0
Nebr:	Omaha	1.21	1.13	<5	<5	24	18	70	40	0	0	0	0
Nev:	Las Vegas	1.19	1.25	<5	<5	6	10	50	55	0	0	0	0
N. H:	Manchester	1.17	1.18	<5	<5	30	22	205	165	0	10	0	10
N. J:	Trenton	1.12	1.14	<5	<5	18	17	85	70	0	10	0	0
N. Mex:	Albuquerque	1.19	1.24	<5	<5	9	9	45	45	0	0	0	0
N. Y:	Buffalo	1.09	1.14	<5	<5	18	16	105	90	0	0	0	0
	New York	1.09	1.20	<5	<5	25	22	120	95	0	10	0	10
	Syracuse	1.12	1.14	<5	<5	15	16	80	90	0	0	0	0
N. C:	Charlotte	1.17	1.21	<5	<5	38	30	100	65	0	0	0	0
N. Dak:	Minot	1.22	1.23	10	<5	49	35	145	100	0	0	0	0
Ohio:	Cincinnati	1.17	1.19	<5	<5	19	19	60	60	0	0	0	0
	Cleveland	1.12	1.18	<5	5	19	18	90	70	0	0	0	0
Okla:	Oklahoma City	1.12	1.18	<5	10	19	18	50	45	0	0	0	0
Ore:	Portland	1.24	1.30	<5	<5	30	23	165	85	0	0	0	0
Pa:	Philadelphia	1.11	1.20	<5	<5	18	16	80	60	0	0	0	0
	Pittsburgh	1.14	1.19	<5	<5	29	25	120	80	0	0	0	10
P. R:	San Juan	1.15	1.14	<5	<5	12	10	70	50	0	0	0	0
R. I:	Providence	1.13	1.18	<5	<5	23	18	140	95	0	0	0	10
S. C:	Charleston	1.15	1.18	<5	<5	31	28	110	90	0	0	0	0
S. Dak:	Rapid City	1.19	1.10	<5	<5	43	32	125	110	0	0	0	0
Tenn:	Chattanooga	1.20	1.20	<5	10	39	31	90	65	0	0	0	0
	Memphis	1.16	1.19	<5	<5	28	23	55	40	0	0	0	0
Tex:	Austin	1.11	1.17	<5	<5	7	8	35	25	0	0	0	0
	Dallas	1.14	1.18	<5	<5	17	15	45	30	0	0	0	0
Utah:	Salt Lake City	1.27	1.34	<5	<5	25	14	165	65	0	0	0	0
Vt:	Burlington	1.13	1.20	<5	<5	25	23	140	110	0	10	0	0
Va:	Norfolk	1.13	1.20	<5	5	23	19	75	55	0	0	0	0
Wash:	Seattle	1.23	1.24	5	5	28	24	170	90	0	0	0	0
	Spokane	1.22	1.31	<5	<5	26	21	130	95	0	0	0	0
W. Va:	Charleston	1.13	1.16	<5	<5	24	17	50	40	0	0	0	0
Wis:	Milwaukee	1.19	1.24	<5	<5	14	15	95	80	0	10	0	0
Wyo:	Laramie	1.18	1.22	<5	<5	20	15	105	75	0	0	0	0
Network average		1.17	1.21	<5	<5	22.3	19.1	94	72	0	<10	0	<10

year. The last column in table 2 shows the most recent issue in which a graph of the strontium-90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentrations in milk was given for March 1960-March 1964 in the July 1964 issue of *RHD* (*2*).

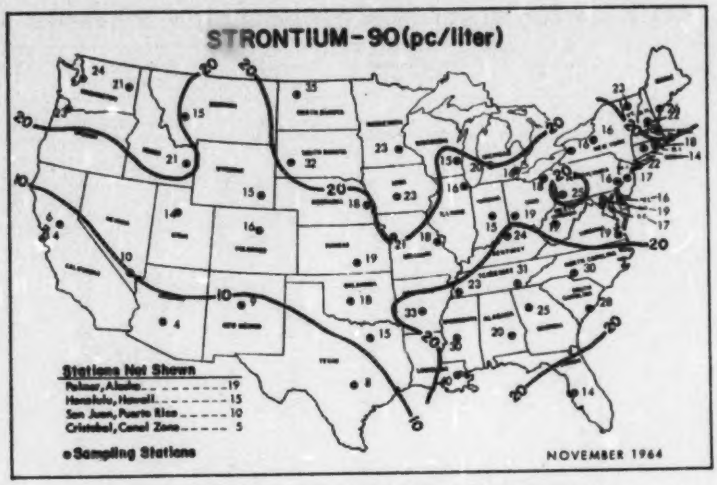
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 19
Honolulu, Hawaii 15
San Juan, Puerto Rico 10
Cristobal, Canal Zone 5
● Sampling Stations
NOVEMBER 1964

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, NOVEMBER 1964

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES FOR STRONTIUM-90, JUNE–NOVEMBER 1964 AND NOVEMBER 1963

Range (pc/liter)	Number of stations in range						
	1964						1963
	June	July	Aug.	Sept.	Oct.	Nov.	Nov.
Under 10	4	6	7	8	6	6	6
10–19	6	6	23	27	37	31	9
20–29	23	29	23	20	13	19	31
30–39	17	14	6	6	7	6	13
40–49	10	4	4	2	0	1	3
50–59	2	1	0	0	0	0	1
60–69	0	2	0	0	0	0	0
70–79	1	0	0	0	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, JUNE–NOVEMBER 1964 AND NOVEMBER 1963

Range (pc/liter)	Number of stations in range						
	1964						1963
	June	July	Aug.	Sept.	Oct.	Nov.	Nov.
Under 50	1	4	6	14	16	15	2
50–99	19	24	30	33	40	41	21
100–149	24	21	19	13	6	4	22
150–199	13	8	6	2	0	2	10
200–249	4	3	1	1	1	1	5
250–299	2	2	1	0	0	0	3

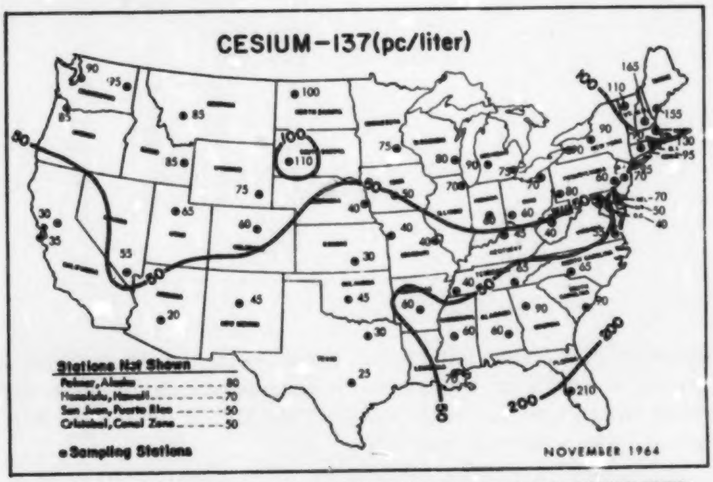
CESIUM–137(pc/liter)
Stations Not Shown
Palmer, Alaska 80
Honolulu, Hawaii 70
San Juan, Puerto Rico 50
Cristobal, Canal Zone 50
● Sampling Stations
NOVEMBER 1964

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, NOVEMBER 1964

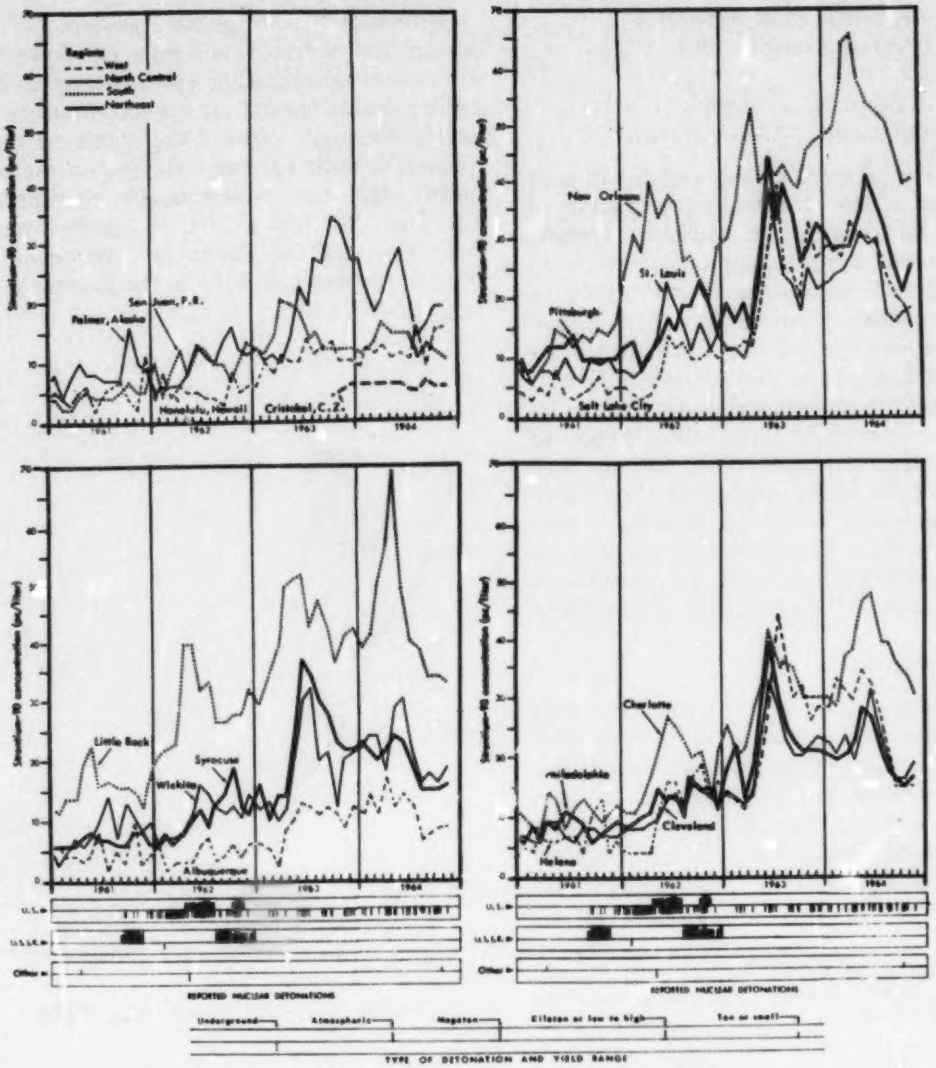

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–NOVEMBER 1964

2. California Milk Network[3], July-September 1964

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino County milksheds to the program in March 1962, weekly or biweekly sampling of pasteurized milk has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

Analytical procedures

After precipitation of the proteins with trichloroacetic acid, yttrium-90 is separated and beta counted. Total radiostrontium remaining in the filtrate is determined by beta counting in a low background counter, usually for a 60-minute period. Strontium-90 is determined from the yttrium-90 results; strontium-89 is determined by difference.

Potassium-40, iodine-131, cesium-137 and barium-140 in whole fluid milk are determined by gamma scintillation spectroscopy using a sodium-iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium-40 concentration (pc/liter) by 1.18 x 10^{-3}. A more complete description of the laboratory equipment and procedures was published in the February 1963 issue of *RHD* (*3*).

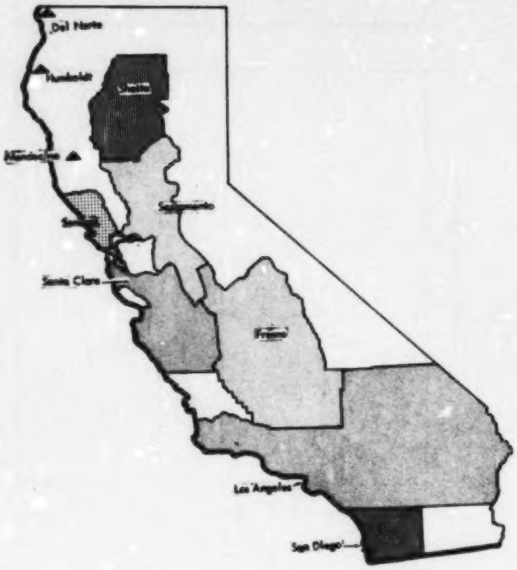

FIGURE 4.—CALIFORNIA MILKSHEDS

TABLE 5.—RADIONUCLIDES IN CALIFORNIA MILK,[a] JULY-SEPTEMBER 1964

[Radioactivity concentrations in pc/liter]

Element and month		Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)	July	1.25	1.20	1.24	1.20	1.15	1.18	1.10	1.20	1.05	1.20	1.18
	Aug	1.33	1.10	1.14	1.00	1.20	1.10	1.10	1.10	1.10	1.20	1.14
	Sept	1.30	1.20	1.28	0.96	1.20	1.20	1.20	1.20	1.20	1.20	1.19
Potassium-40	July	1,460	1,200	1,170	1,210	1,230	1,170	1,250	1,190	1,240	1,220	1,234
	Aug	1,220	1,210	1,140	1,230	1,190	1,170	1,270	1,320	1,180	1,280	1,221
	Sept	1,010	1,190	1,070	1,200	1,210	1,210	1,230	1,180	1,240	1,210	1,175
Strontium-89	July	14	[b]	2	[b]	[b]	[b]	[b]	[b]	[b]	[b]	2
	Aug	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]
	Sept	[b]	[b]	9	[b]	[b]	[b]	[b]	[b]	[b]	[b]	1
Strontium-90	July	54	3.9	14	3.8	6.4	11.0	4.3	4.9	12.1	6.1	12.0
	Aug	56	4.0	11	6.2	7.4	4.5	3.3	3.9	7.3	4.0	10.8
	Sept	32	4.2	13	3.7	6.0	5.7	3.1	6.5	5.6	5.2	8.5
Cesium-137	July	155	26	40	23	31	25	15	34	44	34	43
	Aug	110	18	27	16	28	26	13	20	41	27	33
	Sept	54	18	18	14	18	21	11	24	25	18	22

[a] No significant amounts of iodine-131 or barium-lanthanum-140 in samples for this period were found.
[b] No detectable activity.

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[3] Data from *Radiological Health News, Vol. 3,* No. 4, Bureau of Radiological Health, State of California Department of Public Health, 2151 Berkeley Way, Berkeley 4, California.

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Results

The monthly averages of the radionuclide and calcium data for milk for the period July-September 1964 are presented in table 5. Background information on the differences among the California milksheds was presented by Heslep and Cornish in the December 1963 issue of *RHD* (*4*).

3. Florida Milk Network, January-June 1964

Division of Radiological and Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine-131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium-89, strontium-90 and cesium-137 in addition to iodine-131. Raw milk samples are received from the six areas shown in figure 5. Samples for iodine-131 analysis are taken from a tank truck, the route of which passes by farms widely dispersed over the area represented. Where there is no route representative of a large portion of the area, samples are collected from selected farms and combined. Presently, the sampling is on a monthly basis. Samples were collected weekly when iodine-131 was detectable in milk. A regional State Board of Health Laboratory is located in each area of the State where samples representing raw milk production are collected. For strontium-89, strontium-90 and cesium-137 analysis, monthly composite samples are prepared by each regional laboratory from a randomly selected 10 percent of the farms which have their milk regularly sampled for bacteriological analyses by the county health departments. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms—using locally grown feeds in the "West Florida" region—to larger farms using different types of grass and predominantly purchased feeds in the southern areas.

Analytical procedures

Cesium-137 is determined by gamma scanning one liter or 3.5 liters of milk as received in a Marinelli beaker on a 4" x 4" NaI crystal and multichannel analyzer. The sample is then prepared for radiostrontium analysis by evaporating and ashing one liter.

Strontium is precipitated as a carbonate and stored for yttrium ingrowth. After the ingrowth period, yttrium is separated with carrier as an oxalate and counted in a low-background beta counter to determine strontium-90. Strontium is precipitated as carbonate and counted for total radiostrontium activity. Strontium-89 is then calculated by difference.

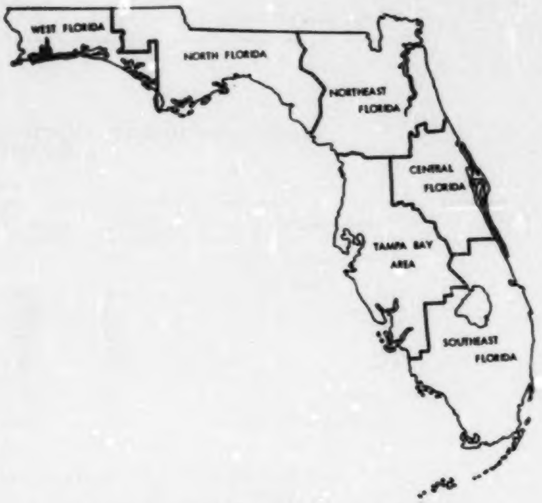

FIGURE 5.—FLORIDA MILK SAMPLING LOCATIONS

Results

Table 6 presents the available monthly average strontium-89 and strontium-90 concentrations in Florida raw milk during January-April 1964. Table 7 presents cesium-137 and iodine-131 results for January-June 1964. Strontium-89, strontium-90, and cesium-137 results for 1963 appeared in the October 1964 issue of *RHD* (*5*). The results for 1963 appeared in the March 1964 issue of *RHD* (*6*). A comparison of these data indicate that during the early part of 1964 Florida milk had lower strontium-89 levels but higher strontium-90 levels than were observed in the preceding 9 months.

Table 6.—STRONTIUM-89 AND STRONTIUM-90 IN FLORIDA RAW MILK, JANUARY–APRIL 1964

[pc/liter]

Radionuclide and month	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay	Southeast Florida	Average
Strontium-89							
January	<5	<5	<5	<5	<5	<5	<5
February	<5	<5	<5	<5	<5	<5	<5
March	<5	<5	<5	<5	<5	<5	<5
April	<5	<5	<5	<5	<5	<5	<5
May							
June							
Average	<5	<5	<5	<5	<5	<5	<5
Average (Jan-Dec 1963)	32	32	28	30	26	31	30
Strontium-90							
January	17	16	15	10	8	12	13
February	10	11	10	11	13	10	11
March	13	14	11	12	10	15	13
April	15	17	14	10	15	14	14
Average	13.8	14.5	12.5	10.8	11.5	12.8	12.8
Average (Jan-Dec 1963)	10.4	9.6	9.1	10.1	8.7	9.2	9.5

Table 7.—CESIUM-137 AND IODINE-131 IN FLORIDA RAW MILK, JANUARY–JUNE 1964

[pc/liter]

Radionuclide and month	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay	Southeast Florida	Average
Cesium-137							
January	191	170	159	211	176	201	185
February	192	203	196	244	196	200	206
March	232	175	181	309	234	234	228
April	213	276	278	294	250	251	260
May	305	284	287	363	264	264	295
June	256	240	182	347	261	246	255
Average	232	225	214	295	231	233	238
Average (Apr-Dec 1963)	180	183	228	227	202	218	206
Iodine-131							
January	<2	—	<2	<2	<2	<2	<2
February	<2	—	<2	<2	<2	<2	<2
March	<2	—	<2	<2	<2	<2	<2
April	<2	—	<2	<2	<2	<2	<2
May	<2	—	<2	<2	<2	<2	<2
June	<10	—	<10	<10	<10	<10	<10

4. Oregon Milk Network, June-September 1964

Division of Sanitation & Engineering
Oregon State Board of Health

The Oregon State Board of Health conducts milk monitoring at eight major milk-producing centers throughout the State of Oregon, as shown in figure 6. Half-gallon samples of pasteurized packaged milk are collected statewide on a monthly basis by the Oregon Department of Agriculture and weekly in the Portland area by the city of Portland. The sampling frequency is accelerated to a weekly schedule at those locations having radionuclide concentrations in milk in excess of 100 pc/liter for iodine-131 or 500 pc/liter for cesium-137. The samples are forwarded to the Oregon State

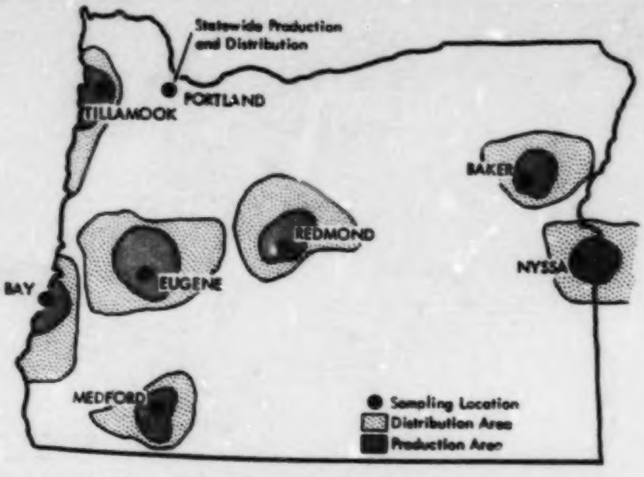

FIGURE 6.—OREGON PASTEURIZED MILK NETWORK SAMPLING LOCATIONS SHOWING PRODUCTION AND DISTRIBUTION AREAS

Board of Health environmental radiation laboratory for iodine-131, cesium-137, barium-140, and strontium-90 analyses. The gamma analyses are performed utilizing a 3" x 3" sodium iodide scintillation detector with a 512-channel gamma spectrometer. Samples are normally counted for 100 minutes. The strontium-90 concentrations reported by the Oregon State Board of Health were obtained by the trichloracetic acid analytical procedure (7) with a low background beta counter equipped with a 2-inch detector used for counting. The minimum detectable concentrations for iodine-131, cesium-137, and barium-140 are 15 pc/liter. The minimum detectable concentration is defined to be that amount of activity which, in the same counting time, gives a count that differs from the background count by 3 times the standard deviation (σ) of the background count.

Table 8 presents the Oregon milk surveillance data for the period June through September 1964. The Portland composite sample represents contributions from nearly all milksheds in Oregon, plus some in southern Washington. Thus, it tends to represent a State average.

TABLE 8.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK, JUNE–SEPTEMBER 1964 [a]

[Average concentrations in pc/liter]

Sampling location and frequency	Nuclide	June	July	Aug.	Sept.
Baker	Strontium-90	22	29	28	[b] —
Monthly	Cesium-137	115	105	135	100
Coos Bay	Strontium-90	43	29	21	—
Monthly	Cesium-137	135	105	90	65
Eugene	Strontium-90	14	12	18	—
Monthly	Cesium-137	125	110	95	75
Medford	Strontium-90	15	22	13	—
Monthly	Cesium-137	125	145	90	55
Nyssa	Strontium-90	25	31	18	—
Monthly	Cesium-137	125	130	90	60
Portland composite	Strontium-90	42	28	[c] 27	[c] 20
Weekly	Cesium-137	223	197	143	96
Portland local producer	Strontium-90	24	33	38	—
Weekly	Cesium-137	168	160	134	90
Redmond	Strontium-90	—	20	20	—
Monthly	Cesium-137	100	120	80	65
Tillamook	Strontium-90	—	29	37	—
Monthly	Cesium-137	340	190	160	180

[a] Iodine-131 and barium-140 concentrations were below the lower limit of detection of 15 pc/liter.
[b] Dash indicates no analysis performed.
[c] Analyses performed by Public Health Service.

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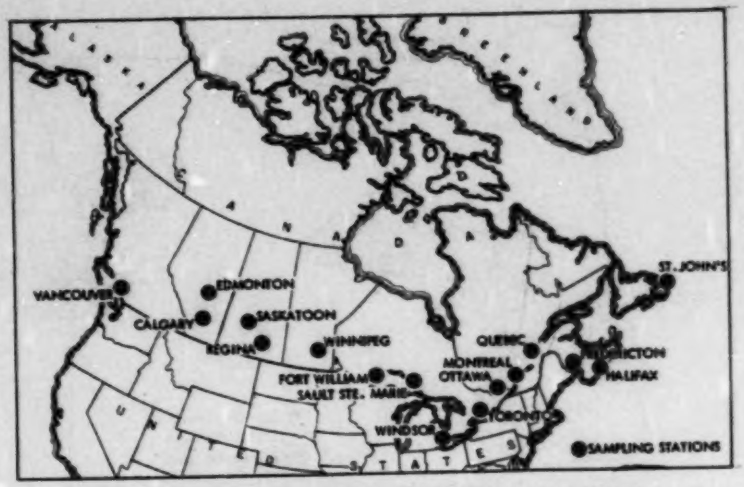

FIGURE 7.—CANADIAN MILK SAMPLING STATIONS

5. Canadian Milk Network[4]
November 1964

Radiation Protection Division,
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 7) in the same areas as the air and precipitation stations. At present the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine-131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450 degrees C., dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

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[4] Data from *Radiation Protection Programs*, Vol. 2, No. 12:25–30 Radiation Protection Division, Canadian Department of National Health and Welfare (Dec. 1964).

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Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 9.

TABLE 9.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 10 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had < 5 pc/liter.

TABLE 10.—RADIONUCLIDES IN CANADIAN WHOLE MILK, OCTOBER 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.20	1.6	27.9	93
Edmonton	1.16	1.6	23.6	94
Ft. William	1.16	1.7	47.2	172
Fredericton	1.16	1.7	35.1	179
Halifax	1.14	1.7	52.3	218
Montreal	1.14	1.6	29.9	138
Ottawa	1.16	1.6	35.4	108
Quebec	1.14	1.7	45.2	214
Regina	1.12	1.7	31.4	104
St. John's, Nfld	1.12	1.6	40.4	177
Saskatoon	1.12	1.6	30.7	100
Sault Ste. Marie	1.18	1.6	37.6	162
Toronto	1.16	1.6	14.6	77
Vancouver	1.23	1.6	44.2	204
Windsor	1.18	1.6	13.5	67
Winnipeg	1.12	1.5	29.9	128
Average	1.16	1.6	33.1	143

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO DOSE ASSESSMENT, DECEMBER 1963–NOVEMBER 1964

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation doses to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to world-wide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*3,4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium-90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium-90 to calcium in milk in a particular locality by 1.5".[1] Thus, a rough index of the total dietary intake of strontium-90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and a 1.0 g daily intake of calcium.

In the case of iodine-131, milk can be considered the major source of intake because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allow time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium-89 is more complicated. Its half-life of about 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake. However, since the time from production to consumption of milk is generally much shorter than for most other food products, the short half-life of strontium-89 would cause milk to contribute relatively more of the total intake of strontium-89 than of strontium-90.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (*6*).

TABLE 1.—AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK, FOR THE TWELVE MONTH PERIODS NOVEMBER 1963–OCTOBER 1964[a] AND DECEMBER 1963–NOVEMBER 1964[b]

[pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Nov 1963–Oct 1964	Dec 1963–Nov 1964	Nov 1963–Oct 1964	Dec 1963–Nov 1964	Nov 1963–Oct 1964	Dec 1963–Nov 1964	Nov 1963–Oct 1964	Dec 1963–Nov 1964
Ala:	Montgomery	3	3	21	23	0	0	84	82
Alaska:	Palmer	6	6	23	21	0	0	141	130
Ariz:	Phoenix	3	3	4	4	0	0	25	26
Ark:	Little Rock	4	3	45	44	0	0	120	122
Calif:	Sacramento	3	3	8	8	0	0	48	45
	San Francisco	4	3	10	10	0	0	54	51
C. Z:	Cristobal	3	3	5	5	0	0	50	51
Colo:	Denver	4	4	19	19	0	0	91	89
Conn:	Hartford	3	3	22	21	0	0	148	142
Del:	Wilmington	3	3	23	23	0	1	133	119
D. C:	Washington	3	3	19	19	0	0	86	82
Fla:	Tampa	3	3	16	15	0	0	236	232
Ga:	Atlanta	4	3	31	31	0	0	130	134
Hawaii:	Honolulu	3	3	11	12	0	0	78	77
Idaho:	Idaho Falls	11	10	27	27	0	0	168	162
Ill:	Chicago	3	3	19	19	0	0	115	112
Ind:	Indianapolis	3	3	21	21	0	1	96	96
Iowa:	Des Moines	6	5	25	25	0	0	91	87
Kans:	Wichita	5	4	21	21	0	0	66	63
Ky:	Louisville	4	3	31	30	0	0	91	88
La:	New Orleans	4	4	51	51	0	0	144	130
Maine:	Portland	3	3	31	30	0	1	201	194
Md:	Baltimore	3	3	22	22	0	0	99	96
Mass:	Boston	3	3	33	32	0	0	222	213
Mich:	Detroit	3	3	19	18	1	2	113	109
	Grand Rapids	3	3	21	21	0	1	134	120
Minn:	Minneapolis	9	7	33	33	0	0	147	141
Miss:	Jackson	5	4	41	41	0	0	107	104
Mo:	Kansas City	7	6	28	27	0	0	81	77
	St. Louis	5	5	23	23	0	0	82	78
Mont:	Helena	6	5	26	25	1	1	175	166
Nebr:	Omaha	6	5	26	26	0	0	95	90
Nev:	Las Vegas	5	5	10	10	1	1	73	72
N. H:	Manchester	3	3	32	30	0	1	236	236
N. J:	Trenton	3	3	19	19	0	1	114	110
N. Mex:	Albuquerque	3	3	11	11	1	1	54	53
N. Y:	Buffalo	3	3	20	20	0	0	141	136
	New York	4	3	26	25	0	1	159	152
	Syracuse	[c]3	[d]3	[c]20	[d]20	[c]0	[d]0	[c]139	[d]134
N. C:	Charlotte	4	3	36	36	0	0	112	109
N. Dak:	Minot	14	12	57	56	0	0	152	149
Ohio:	Cincinnati	3	3	23	23	0	0	92	90
	Cleveland	3	3	21	21	0	0	113	110
Okla:	Oklahoma City	3	3	23	23	0	0	70	68
Ore:	Portland	8	6	31	30	0	0	164	154
Pa:	Philadelphia	3	3	20	20	0	0	119	115
	Pittsburgh	3	3	29	29	0	0	148	143
P. R:	San Juan	3	3	12	12	0	0	73	72
R. I:	Providence	3	3	25	24	0	0	163	157
S. C:	Charleston	3	3	32	32	0	0	127	124
S. Dak:	Rapid City	8	6	43	41	0	0	153	146
Tenn:	Chattanooga	5	4	41	41	0	0	120	116
	Memphis	3	3	32	32	0	0	74	70
Tex:	Austin	3	3	9	9	0	0	41	39
	Dallas	3	3	20	19	0	0	66	62
Utah:	Salt Lake City	8	6	27	25	0	0	178	172
Vt:	Burlington	3	3	26	26	1	2	178	170
Va:	Norfolk	3	3	18	18	0	0	94	91
Wash:	Seattle	7	7	26	26	0	0	152	146
	Spokane	8	6	29	28	0	0	143	136
W. Va:	Charleston	4	3	27	26	0	0	81	78
Wis:	Milwaukee	3	3	18	18	0	1	130	125
Wyo:	Laramie	8	8	21	20	0	0	107	104
Network average		4	4	24.5	24.1	<10	<10	118	113

Note: Annual averages for Barium-140 at each station were <10.

[a] Annual averages were computed on basis of 53 weekly averages.

[b] Annual averages were computed on basis of 52 weekly averages.

[c] Annual averages were computed on basis of 49 weekly averages. No samples were collected during July 1964.

[d] Annual averages were computed on basis of 48 weekly averages. No samples were collected during July 1964.

The relative contribution of milk to the total dietary intake of cesium-137 is not well defined and depends principally on the amount of freshly deposited cesium-137 on products used for human and animal consumption, and the progress of cesium-137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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[2] Beginning with the October 1963 data, iodine-131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

STRONTIUM-90 IN TRI-CITY DIETS, MAY-JULY 1964[1]

Health and Safety Laboratory, AEC

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U. S. Department of Agriculture (*1*) the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data (*1*) are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results obtained from the May-July 1964 sampling are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

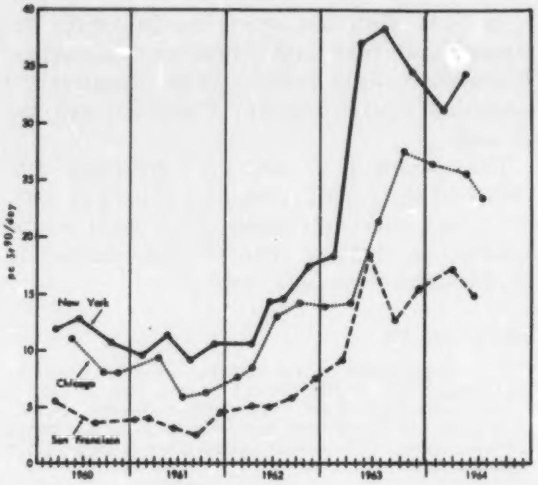

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

Discussion

The previously noted geographic distribution pattern of strontium-90 in the diet is seen to persist as it has since the initial samplings in 1960: Levels have been highest in New York City and lowest in San Francisco. Due in part to its high annual consumption, milk continues to be the predominant source of strontium-90 in diet.

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[1] Data from *Fallout Program Quarterly Summary Report, HASL-155*:208–10, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (January 1, 1965) price $4.00.

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TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE, MAY–JULY 1964 SAMPLING

Food category	Average U.S. consumption		New York City May 1964		Chicago July 1964		San Francisco June 1964	
	diet (kg/yr)	Calcium (g/yr)	pc/kg [a]	pc/yr	pc/kg [a]	pc/yr	pc/kg [a]	pc/yr
Bakery products	37	37.0	29.8±1.6	1103	40.3±1.5	1491	26.3±1.5	973
Whole grain products	11	10.0	87.9±2.3	967	83.3±1.9	916	50.9±2.1	560
Eggs	16	9.1	6.5±0.2	104	9.8±0.2	157	1.8±0.1	28
Fresh vegetables	43	15.0	20.3±0.5	873	13.3±0.5	572	22.4±0.6	963
Root vegetables	17	6.1	8.6±0.5	146	7.0±0.3	119	6.9±0.6	117
Milk	221	234.3	32.0±0.8	7,072	16.2±0.6	3,580	8.7±0.5	1,923
Poultry	17	9.2	2.8±0.2	48	3.5±0.8	60	2.2±0.1	37
Fresh fish	8	10.8	0.6±0.1	5	2.1±0.1	17	0.6±0.1	5
Flour	43	8.6	32.6±0.6	1,402	21.2±0.4	912	12.7±0.4	546
Macaroni	3	0.7	16.6±0.5	50	28.0±0.5	84	12.4±0.5	37
Rice	3	1.1	4.4±0.2	13	6.1±0.2	18	0.4±0.1	1
Meat	73	10.9	1.7±0.4	124	2.2±0.1	161	2.1±0.1	153
Shellfish	1	0.8	2.7±0.1	3	1.4±0.1	1	4.5±0.2	4
Dried beans	3	2.9	36.0±2.2	108	35.6±2.0	107	13.6±1.6	41
Fresh fruit	68	12.6	8.0±0.3	544	4.2±0.2	286	0.4±0.1	27
Potatoes	45	5.8	7.8±0.7	351	3.1±0.3	140	3.6±0.4	162
Canned fruit	26	1.3	2.8±0.2	73	3.6±0.1	94	1.5±0.1	39
Fruit juices	19	1.7	3.2±0.3	61	5.6±0.2	106	4.2±0.3	80
Canned vegetables	20	4.2	6.7±0.6	134	10.9±0.5	218	3.6±0.5	72
Annual intake	674	383	19.6	13,181	13.4	9,039	8.6	5,768
pc Sr^{90}/g Ca in total diet				34.4		23.6		15.0

[a] Error terms are one standard deviation (due to counting).

In New York the strontium-90 intake increased over that found three months earlier. There was a slight decrease in the strontium-90 estimated intakes for San Francisco and for Chicago.

The maximum in late 1963 reflecting late 1961 and early 1962 atmospheric nuclear testing is seen to be decreasing. This trend can be expected to continue with the discontinuation of atmospheric nuclear testing.

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Recent coverage in *Radiological Health Data:*

Period	Issue
Thirteenth sampling (May–July 1963)	*March 1964*
Fourteenth sampling (August–October 1963)	*June 1964*
Fifteenth sampling (November 1963–January 1964)	*September 1964*
Sixteenth Sampling (February 1964–April 1964)	*December 1964*

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ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS, JANUARY-JUNE 1964

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (1).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other source. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected once every two months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitions indicating the types and quantities of food included.

Analytical procedures

After weighing at the Laboratory, each sample is homogenized, dried, and ashed prior to stable calcium, potassium, strontium, and sodium determinations.

The radiochemical analyses are based upon three basic procedures: chemical separations of strontium-89 and strontium-90; radium-226 analysis; and gamma spectroscopy of the entire wet sample.

TABLE 1.—ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS,[a] JANUARY-FEBRUARY 1964

City	Kg/capita per day [b]	pc/capita/day							grams/capita/day [c, d]			
		Sr-89	Sr-90	Ra-226	Cs-137	Zr-95	Mn-54	Ce-141, Ce-144	K	Na	Ca	Sr
Bakersfield	2.1	8.1	12	0.7	54	48	[e] —	0.8	2.7	3.6	0.8	0.003
Berkeley	2.5	1.5	17	0.5	77	80	—	5.8	3.5	4.0	0.6	0.004
Bishop	1.0	6.2	19	2.6	63	35	1.2	2.0	2.3	2.5	0.7	0.004
Brawley	2.7	4.8	7	1.0	39	44	8.2	7.5	3.6	4.7	1.2	0.006
Crescent City	2.9	24.0	70	1.1	173	67	5.1	11.0	3.7	4.0	1.5	0.007
Eureka	3.1	—	—	3.1	79	17	4.6	7.0	2.3	3.0	—	0.003
Fresno	2.7	3.9	17	2.3	41	41	13	6.5	3.7	5.2	1.2	0.005
Los Angeles	1.9	5.6	5	2.5	—	—	—	—	1.2	3.5	0.7	0.003
Needles	1.3	0.7	15	1.3	73	3.7	—	2.5	2.7	4.8	1.0	0.003
Quincy	2.5	0	15	0.8	88	51	1.6	2.4	1.7	4.1	1.1	0.004
Redding	1.5	2.2	2.3	0.6	41	31	3.1	1.0	2.2	5.3	0.9	0.008
Sacramento	2.7	1.2	21	0.8	81	49	9.3	0.8	3.2	4.7	1.2	0.004
Salinas	2.4	3.5	11	0.1	144	40	4.6	0.4	3.1	2.6	0.7	0.003
San Bernardino	2.6	0.6	15	1.2	—	—	—	—	1.9	4.9	0.9	0.005
San Diego	2.1	0.3	—	1.6	47	44	3.4	3.6	3.1	7.8	1.1	0.012
San Luis Obispo	1.7	0.4	2	1.5	28	31	5.2	4.2	2.0	3.1	1.2	0.005
Santa Barbara	3.0	3.0	6	0.2	—	—	—	—	1.6	2.2	0.4	0.003
Santa Rosa	2.0	2.0	13	0.3	59	69	—	3.8	2.8	2.7	1.0	0.003
Susanville	2.1	7.9	11	—	80	41	2.2	3.1	1.4	3.6	0.8	0.003
Ukiah	2.2	4.9	15	1.0	55	54	13	2.4	3.1	2.6	1.7	0.003

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive K-40.
[d] Stable strontium consists of Sr-88—82.7 percent; Sr-87—7.0 percent; Sr-86—9.8 percent; Sr-84—0.5 percent; total—100.0 percent.
[e] Dash indicates sample lost in laboratory procedures.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in tables 1–3 for January through June 1964 (*2*).

It should be noted that levels of radioactvity were observed to be far below those levels for which consideration should be given to protective health action.

TABLE 2.—ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS,[a] MARCH–APRIL 1964

City	Kg/capita per day [b]	pc/capita/day							grams/capita/day [c, d]			
		Sr-89	Sr-90	Ra-226	Cs-137	Zr-95	Mn-54	Ce-141, Ce-144	K	Na	Ca	Sr
Bakersfield	2.2	8.0	13	2.7	108	52	3.3	0	3.3	4.6	1.3	0.07
Berkeley	2.6	1.1	27	1.0	86	44	[b]	0	3.2	4.9	1.4	0.07
Bishop	1.4	2.0	8	0.9	51	28	7.1	7.0	1.8	2.4	0.5	0.04
Brawley	2.6	3.3	12	2.0	27	44	0	22	3.0	4.4	1.4	0.08
Crescent City	2.3	5.5	68	2.9	—	—	—	—	3.2	4.1	1.2	0.06
Eureka	2.1	6.3	38	0.7	80	52	8.9	18	2.5	3.1	1.3	0.07
Fresno	2.3	0	33	1.3	—	—	—	—	3.5	5.5	1.3	0.08
Los Angles	2.7	0	14	0.2	87	56	—	0	2.8	3.7	0.8	0.06
Quincy	1.3	3.3	7	0.9	—	—	—	—	1.8	2.8	0.5	0.02
Redding	2.2	10	14	2.4	55	35	—	95	2.8	4.3	0.9	0.06
Sacramento	2.6	0	15	1.4	85	36	0	2.6	4.8	8.3	1.7	0.13
Salinas	2.3	4.2	18	0.9	55	39	0	1.6	2.9	3.6	0.8	0.06
San Bernardino	1.9	8.0	11	0.6	48	36	2.7	3.8	3.0	4.1	1.0	0.07
San Diego	2.2	3.5	2	0.3	45	42	0.7	0	2.8	3.6	0.7	0.07
San Luis Obispo	1.6	1.7	10	0.8	38	33	8.3	6.9	2.0	3.2	0.7	0.05
Santa Barabara	1.9	0	15	0.6	62	31	0	0	2.3	3.1	1.0	0.02
Santa Rosa	2.5	0	27	0.6	77	34	0	0	3.1	3.3	1.4	0.04
Susanville	2.3	3.9	14	0.6	108	52	3.3	0	2.3	3.1	0.8	0.03
Ukiah	2.1	0.6	14	1.5	67	41	—	0	3.0	2.7	0.9	0.04

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Dash indicates sample lost in laboratory procedures.

TABLE 3.—ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS,[a] MAY–JUNE 1964

City	Kg/capita per day [b]	pc/capita/day							grams/capita/day [c, d]			
		Sr-89	Sr-90	Ra-226	Cs-137	Zr-95	Mn-54	Ce-141, Ce-144	K	Na	Ca	Sr
Bakersfield	2.2	3.1	13	0.5	64	54	0	28	3.0	4.1	1.2	0.03
Berkeley	2.9	7.0	14	1.2	60	37	0	34	3.9	5.3	1.1	0.09
Bishop	1.4	3.5	9.0	0.4	37	27	0.4	30	2.0	2.1	0.6	0.02
Brawley	2.4	0	41	0.1	75	3.0	[b]	87	3.3	4.3	1.0	0.04
Crescent City	2.2	0	38	0.8	93	28	16	72	2.6	3.3	0.9	0.04
Eureka	2.3	—	—	1.1	92	37	—	0	2.8	3.2	1.2	0.05
Fresno	2.3	0	28	0.6	65	34	1.6	0	3.0	4.2	0.9	0.04
Los Angles	2.7	0.2	11	0.8	61	47	0	18	3.0	3.2	0.8	0.02
Needles	2.3	0	15	0.6	63	27	10	0	3.0	3.6	1.0	0.03
Quincy	1.8	0	17	0.6	103	144	106	0	2.3	4.6	0.4	0.07
Redding	2.5	1.0	27	1.0	100	39	20	0	3.3	5.7	1.1	0.04
Sacramento	3.4	13	17	1.8	85	41	12	72	3.9	6.8	1.3	0.06
Salinas	2.4	0	27	0.6	92	9.3	3.2	11	3.4	5.7	0.7	0.07
San Bernardino	2.1	0.4	11	0.9	52	39	0.5	8.2	3.2	3.8	0.9	0.03
San Diego	2.0	0	20	1.6	65	30	1.1	0	2.8	3.8	1.1	0.04
San Luis Obispo	1.4	0	14	0.8	51	44	0	0	1.9	3.8	0.6	0.03
Santa Barbara	1.8	0	14	1.4	—	—	—	—	2.5	3.6	0.8	0.05
Santa Rosa	2.4	0	36	2.0	39	32	0	72	2.8	3.3	0.9	0.03
Susanville	2.3	0	17	0.7	95	35	4.3	0.5	3.0	3.2	0.8	0.03
Ukiah	2.3	11	20	0.6	80	32	14	68	3.1	3.9	1.5	0.08

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Dash indicates sample lost in laboratory procedures.

REFERENCES

1. Bureau of Radiological Health, State of California, Department of Public Health. Rad Health News 3:10 (July 1964). 2151 Berkeley Way, Berkeley 4, California.
2. Ibid., p. 34.

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Section III—Water

Gross Radioactivity and Strontium-90 in Surface Waters of the United States, September 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 131 stations as of February 1, 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–7*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on either monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at all newly established stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counter.

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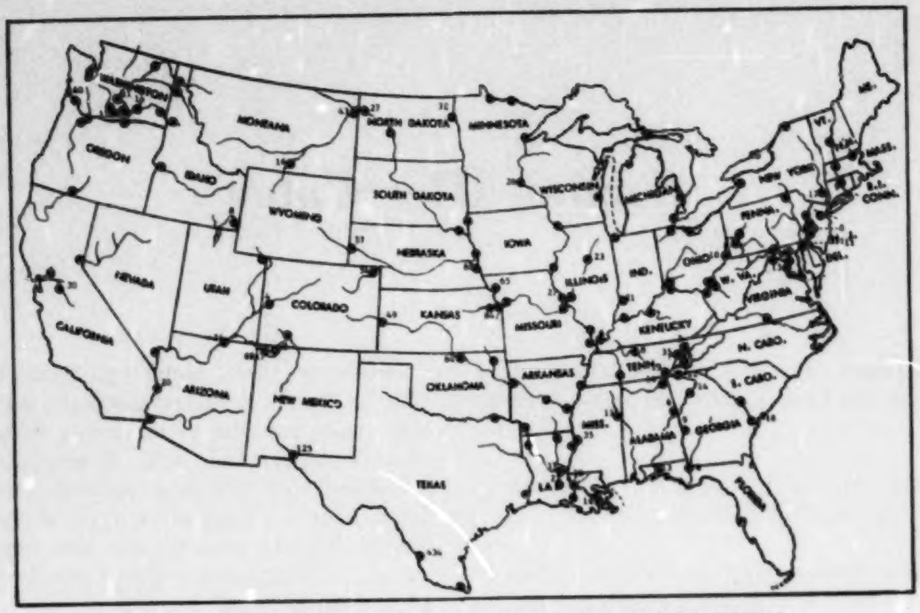
WASHINGTON
MONTANA
NORTH DAKOTA
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OREGON
IDAHO
SOUTH DAKOTA
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MICHIGAN
NEW YORK
R.I.
CONN.
WYOMING
IOWA
NEBRASKA
PENNA.
NEVADA
UTAH
COLORADO
KANSAS
ILLINOIS
IND.
OHIO
W. VA.
VIRGINIA
CALIFORNIA
MISSOURI
KENTUCKY
N. CARO.
TENN.
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
LA.
FLORIDA

FIGURE 1.—SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, OCTOBER 1964

Results

Table 1 presents September 1964 results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1 which gives the June 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

Strontium-90 determinations and results

Beginning in 1959, strontium-90 analyses of the total solids of surface waters were made quarterly on three-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except at those stations immediately below nuclear installations, where quarterly analyses were continued. The method used for determining strontium-90 is a modification of a procedure described by Harley (*10*). The yttrium-90 together with an yttrium carrier is precipitated as yttrium oxalate and the latter is washed and counted in a low-background anticoincidence, end-window proportional counter.

Table 2 presents the results of quarterly analyses of strontium-90 concentrations in U.S. surface waters for July-September 1964 as well as results for the previous three quarters for comparative purposes. The stations are arranged in the table according to their relative locations on the river, the first station being closest to the headwaters. Floyd and Weaver summarized the strontium-90 results

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, SEPTEMBER 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	4	14	18	1	1	2
Apalachicola River:						
Chattahoochee, Fla.	2	2	4	0	0	0
Arkansas River:						
Coolidge, Kansas	6	43	49	0	12	12
Ponca City, Okla.	53	31	84	9	0	9
Atchafalaya River:						
Morgan City, La.	7	16	23	0	1	1
Bear River:						
Preston, Idaho	0	8	8	0	2	2
Big Horn River:						
Hardin, Mont.	7	9	16	1	10	11
Chattahoochee River:						
Atlanta, Ga.	5	9	14	<1	0	<1
Columbus, Ga.	2	7	9	0	0	0
Lanett, Ala.	2	4	6	0	0	0
Chena River:						
Fairbanks, Alaska	1	8	9	0	1	1
Clinch River:						
Clinton, Tenn.	0	7	7	0	0	0
Kingston, Tenn.	12	23	35	0	0	0
Colorado River:						
Loma, Colo.	4	0	4	1	17	18
Page, Ariz.	1	34	35	0	5	5
Parker Dam, Calif-Ariz.	1	19	20	0	10	10
Columbia River:						
Wenatchee, Wash.	0	11	11	0	0	0
Pasco, Wash.	123	981	1104	0	1	1
Clatskanie, Ore.	18	150	168	<1	<1	<1
Connecticut River:						
Enfield Dam, Conn.	0	9	9	0	0	0
Cumberland River:						
Cheatham Lock, Tenn.	0	8	8	0	0	0
Delaware River:						
Philadelphia, Pa.	1	7	8	0	0	0
Escambia River:						
Century, Fla.	5	8	13	1	0	1
Great Lakes:						
Duluth, Minn.	0	1	1	0	0	0
Hudson River:						
Poughkeepsie, N.Y.	4	13	17	0	0	0
Illinois River:						
Grafton, Ill.	6	17	23	1	2	3
Kansas River:						
De Soto, Kans.	51	33	84	7	1	8
Maumee River:						
Toledo, Ohio	4	18	22	1	1	2
Mississippi River:						
St. Paul, Minn.	1	27	28	0	2	2

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
E. St. Louis, Ill.	8	19	27	1	2	3
New Roads, La.	13	22	35	2	1	3
New Orleans, La.	11	19	30	1	1	2
Missouri River:	0	16	16	0	1	1
Williston, N. Dak.						
St. Joseph, Mo.	5	22	27	0	4	4
North Platte River:	34	31	65	10	4	14
Henry, Nebr.						
Ohio River:	3	34	37	0	21	21
Cairo, Ill.						
Toronto, Ohio	0	6	6	0	1	1
Platte River:	2	16	18	0	0	0
Plattsmouth, Nebr.						
Potomac River:	58	22	80	12	3	15
Washington, D.C.						
Red River, North:	2	11	13	0	0	0
Grand Forks, N. Dak.						
Red River, South:	2	30	32	0	1	1
Alexandria, La.						
Rio Grande River:	13	20	33	2	1	3
El Paso, Tex.						
Laredo, Tex.	96	29	125	25	0	25
San Joaquin River:	418	16	434	73	1	74
Vernalis, Calif.						
San Juan River:	6	24	30	1	7	8
Shiprock, N. Mex.						
Savannah River:	855	26	881	264	6	270
Port Wentworth, Ga.						
Snake River:	5	13	18	0	0	0
Wawawai, Wash.						
South Platte River:	3	11	14	0	2	2
Julesburg, Colo.						
Susquehanna River:	3	51	54	0	18	18
Conowingo, Md.						
Tennessee River:	2	9	11	0	0	0
Lenoir City, Tenn.						
Chattanooga, Tenn.	1	7	8	0	0	0
Bridgeport, Ala.	2	10	12	0	<1	<1
Pickwick Landing, Tenn.	0	14	14	1	0	1
Tombigbee River:	2	11	13	0	<1	<1
Columbus, Miss.						
Wabash River:	3	8	11	0	0	0
New Harmony, Ind.						
Yellowstone River:	8	13	21	0	<1	<1
Sidney, Mont.						
	25	18	43	3	3	6
Maximum	855	981	1104	264	21	270
Minimum	0	0	1	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*11*).

Sixty-seven quarterly composite samples were analyzed for strontium-90 activity in July-September 1964. The arithmetic mean for these results was 2.8 pc/liter. The mean for 69 results of the previous quarter was 3.0 pc/liter. These values are essentially the same, although different sets of stations were sampled in each quarter.

The highest strontium-90 result for this quarter (8.2 pc/liter) occurred, as it did the previous quarter, at Grand Forks, North Dakota (Red River, North). While there are no standards for strontium-90 activity of total solids in surface water, the Public Health Service Drinking Water Standards set the limit for strontium-90 concentrations in drinking water at 10 pc/liter (*11*). This limit for public water supplies is greater than the highest level observed during July-September 1964.

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter at only two stations, the Pasco, Washington, station and the Clatskanie, Oregon, station on the Columbia River. The dissolved beta activity values observed were 981 and 150 pc/liter, respectively.

Dissolved alpha activity, associated with the dissolving of natural surface minerals by water, ranged from 0 to 21 pc/liter. Four stations had monthly average dissolved alpha activity greater than 10 pc/liter.

TABLE 2.—QUARTERLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN SURFACE WATERS, OCTOBER 1963-SEPTEMBER 1964

[Concentrations in pc/liter]

Station	Oct.-Dec. 1963	Jan.-Mar. 1964	Apr.-June 1964	July-Sept. 1964
Allegheny River:				
Pittsburgh, Pa.	2.8		2.3	
Animas River:				
Cedar Hill, N. Mex.		1.7		1.5
Apalachicola River:				
Chattahoochee, Fla.		1.5		1.6
Arkansas River:				
Coolidge, Kans.		0.9		2.5
Ponca City, Okla.	4.4		6.0	
Fort Smith, Ark.		3.5		4.8
Little Rock, Ark.	4.4		4.2	
Pendleton Ferry, Ark.	4.3		4.4	
Atchafalaya River:				
Morgan City, La.[a]				4.0
Bear River:				
Preston, Idaho		1.1		2.5
Big Horn River:				
Hardin, Mont.	2.3		6.4	
Big Sioux River:				
Sioux Falls, S. Dak.	5.0	2.8		4.6
Chattahoochee River:				
Atlanta, Ga.	1.7		2.4	
Columbus, Ga.	1.7		2.0	
Lanett, Ala.		1.7		1.8
Chena River:				
Fairbanks, Alaska	0.2		0.8	
Clearwater River:				
Lewiston, Idaho		0.8		1.0
Clinch River:				
Clinton, Tenn.		2.0		1.3
Kingston, Tenn.	6.5	7.5	4.9	3.3
Colorado River:				
Loma, Colo.	1.4		3.5	
Page, Ariz.		5.9		4.9
Boulder City, Nev.	1.5		1.6	
Parker Dam, Calif-Ariz.		1.9		2.2
Yuma, Ariz.	1.1		1.0	
Columbia River:				
Northport, Wash.		1.5		2.1
Wenatchee, Wash.	2.8		1.2	
Pasco, Wash.	3.4	3.1	1.7	2.5
McNary Dam, Ore.	2.5	2.2	1.1	1.6
Bonneville, Ore.		3.0		1.6
Clatskanie, Ore.	1.6		1.0	
Connecticut River:				
Wilder, Vt.		1.3		1.4
Northfield, Mass.	1.6		1.5	
Enfield Dam, Conn.		1.7		1.9
Coosa River:				
Rome, Ga.[b]				1.7
Cumberland River:				
Clarksville, Tenn[c]				
Cheatham Lock, Tenn[d]				1.7
Cuyahoga River:				
Cleveland, Ohio		4.3		4.5
Delaware River:				
Martins Creek, Pa.	1.6		1.5	
Trenton, N. J.		1.8		1.7
Philadelphia, Pa.	2.1		2.0	
Escambia River:				
Century, Fla.	1.2		1.8	
Great Lakes:				
Duluth, Minn.	0.7		0.7	
Sault Ste. Marie, Mich.		0.8		0.8
Milwaukee, Wis.	0.8		1.2	
Gary, Ind.		1.2		1.0
Port Huron, Mich.	1.2		1.5	
Detroit, Mich.		1.4		1.0
Buffalo, N. Y.	5.0		2.7	
Green River:				
Dutch John, Utah		4.6		4.4
Hudson River:				
Poughkeepsie, N. Y.	5.0		2.1	
Illinois River:				
Peoria, Ill.	2.3		3.8	
Grafton, Ill.		3.8		3.4
Kanawha River:				
Winfield Dam, W. Va.		1.1		1.8
Kansas River:				
De Soto, Kans.	5.2		5.9	
Klamath River:				
Keno, Ore.	1.8		1.7	
Little Miami River:				
Cincinnati, Ohio	1.4	3.3		2.4
Maumee River:				
Toledo, Ohio	2.7		4.2	
Merrimack River:				
Lowell, Mass.		1.8		2.6
Mississippi River:				
St. Paul, Minn.	4.3	3.2		5.3
Dubuque, Iowa	3.7		5.2	
Burlington, Iowa	4.3	2.8		4.4
E. St. Louis, Ill.	3.8		4.9	
Cape Girardeau, Mo.		2.9		4.2
W. Memphis, Ark.	3.6		4.3	
Vicksburg, Miss.		2.7		3.7
Delta, La.	3.4		3.6	
New Roads, La[e]			3.6	
New Orleans, La.		3.8		3.7
Missouri River:				
Williston, N. Dak.	2.8		3.1	
Bismarck, N. Dak.		3.9		4.0
Yankton, S. Dak.	3.3		4.3	
Omaha, Nebr.		3.3		4.4
St. Joseph, Mo.	3.4		6.4	
Kansas City, Kans.		2.9		3.8
Missouri City, Mo.	4.1		9.4	
St. Louis, Mo.		3.1		5.0
Monongahela River:				
Pittsburgh, Pa.	3.3		2.1	
North Platte River:				
Henry, Nebr.	0.7		3.3	
Ohio River:				
Toronto, Ohio	2.8		2.3	
Addison, Ohio		2.2		3.4
Huntington, W. Va.	3.0		2.2	
Cincinnati, Ohio		1.6		3.2
Louisville, Ky	4.0		2.6	
Evansville, Ind.		2.5		3.0
Cairo, Ill.	2.8		3.4	
Ouachita River:				
Bastrop, La.		3.0		2.5
Pend Oreille River:				
Albeni Falls Dam, Idaho	1.3		1.2	
Platte River:				
Plattsmouth, Nebr.		2.1		4.8
Potomac River:				
Williamsport, Md.	1.7		1.3	
Great Falls, Md.		1.4		1.7
Washington, D. C.		1.2		1.9
Rainy River:				
Baudette, Minn.	4.1		4.0	
International Falls, Minn.	3.8		5.0	
Raritan River:				
Perth Amboy, New Jersey (5-ft. Below Surface)				
Perth Amboy, New Jersey (5-ft. Above Bottom)				
Red River, North:				
Grand Forks, N. Dak.	7.1	4.9	9.4	8.2
Red River, South:				
Denison, Tex.		5.8		6.4
Index, Ark.	4.3		5.4	
Bossier City, La.		4.4		5.9
Alexandria, La.	4.1		4.4	
Rio Grande River:				
Alamosa, Colo.	0.8		1.9	
El Paso, Tex.		0.6		2.7
Laredo, Tex.	2.4		5.6	
Brownsville, Tex.		2.6		2.6
Roanoke River:				
John H. Kerr Resr/Dam, Va.	2.6		1.5	
Sabine River:				
Ruliff, Tex.		2.5		2.7
Sacramento River:				
Courtland, Calif.	1.0	1.0		0.9
St. Lawrence River:				
Massena, N. Y.		1.6		1.6
San Joaquin River:				
Vernalis, Calif.	1.5		1.0	
San Juan River:				
Shiprock, N. Mex.	2.1		2.9	
Savannah River:				
North Augusta, So. Car.		1.7		2.1
Port Wentworth, Ga.	2.4	1.7	2.3	2.6
Schuylkill River:				
Philadelphia, Pa.		1.4		1.6
Shenandoah River:				
Berryville, Va.	1.0		1.1	
Ship Creek:				
Anchorage, Alaska		0.4		0.2
Snake River:				
Ice Harbor Dam, Wash.		1.0		1.1
Wawawai, Wash.	0.7		1.0	
Payette, Idaho	0.8		0.9	
South Platte River:				
Julesburg, Colo.	1.8		1.6	
Spokane River:				
Post Falls, Idaho		1.3		0.9
Susquehanna River:				
Sayre, Pa.		1.3		1.7
Conowingo, Md.	3.0		1.3	
Tennessee River:				
Lenoir City, Tenn.	2.1		1.6	
Chattanooga, Tenn.	2.2	2.0	2.3	1.9
Bridgeport, Ala.	2.2		1.5	
Pickwick Landing, Tenn.		2.1		2.4
Tombigbee River:				
Columbus, Miss.		3.1		2.0
Truckee River:				
Farad, Calif.	1.0		1.2	
Verdigris River:				
Nowata, Okla.	6.0		6.6	
Wabash River:				
New Harmony, Ind.	2.5		4.2	
Willamette River:				
Portland, Ore.	0.5		0.3	
Yakima River:				
Richland, Wash.		0.3		0.3
Yellowstone River:				
Sidney, Mont.		1.9		3.2
Maximum	7.1	7.5	9.4	8.2
Minimum	0.2	0.3	0.3	0.2

[a] Activated 5-15-64.
[b] Activated 8-64.
[c] Deactivated 7-22-64.
[d] Relocated
[e] Activated 5-15-64.

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*12*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pc/liter (*11*). Analysis of the preliminary September 1964 data indicates elevated levels of alpha and beta activity (pc/liter) in the suspended solids fraction. The monthly average suspended alpha and beta activities in the San Juan River at Shiprock, New Mexico, were 264 and 855 pc/liter, respectively. At El Paso, Texas, and Laredo, Texas, on the Rio Grande the suspended alpha activities were 25 and 73 pc/liter and the suspended beta activities were 96 and 418 pc/liter, respectively. The dissolved alpha and beta activities were not significantly different from those commonly observed at this sampling station. The samples associated with these unusually high averages contained large quantities of suspended solids. Thus, only quite small aliquots could be used in the laboratory determinations to avoid excessive beta self-absorption. In such cases the relatively large multiplication factor, together with the usual range of counting errors associated with standard counting periods, can result in apparently abnormal levels of radioactivity. The specific activity (pc/g) of the samples discussed above was determined and found to be comparable to specific activities observed normally in samples from this station. The apparent increased activity, therefore, may be attributed to the extremely high suspended solids content of the sample and considered essentially of natural origin.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90 respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

RADIOACTIVITY IN CALIFORNIA SURFACE WATERS,[1] JANUARY-JUNE 1964

Bureau of Radiological Health,
State of California
Department of Public Health

Gross beta results obtained by the Bureau of Radiological Health in its monitoring of California surface water during the period January to June 1964 are summarized below. The importance of this facet of the Bureau's environmental surveillance program stems from the fact that most of California's domestic water supplies come from surface sources. Radioactivity in such water supplies consists of the natural radioactivity in surface streams, any radioactivity that may be added by the discharge of sewage or industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Most of the supplies sampled represent raw surface waters, (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

It is necessary to monitor domestic water supplies on a continuing basis, since it is impossible to forecast levels of radioactivity in these supplies on the basis of radioactivity in rain, snow, or surface streams. The Bureau has established a monthly sampling schedule whereby 500-ml samples are collected and the total solids are analyzed for alpha and beta radioactivity. In addition, a three-liter sample is collected each month for a period of approximately six months to make up a composite of approximately five gallons for specific radionuclide analysis.

Analytical procedures

Radionuclide analyses of water are carried out in the Sanitation and Radiation Laboratory. All measurements of alpha and alpha-plus-beta activities are made with windowless gas-flow proportional counters. Counting methods used are in accordance with U.S. Public Health Service recommended procedures (*1*).

Individual samples are evaporated down to dryness and the residue ashed at 450° C. The ashed sample is dissolved and transferred to an aluminum planchet for beta and alpha-plus-beta counting. Gamma emitting radionuclides are determined for composite samples. Indi-

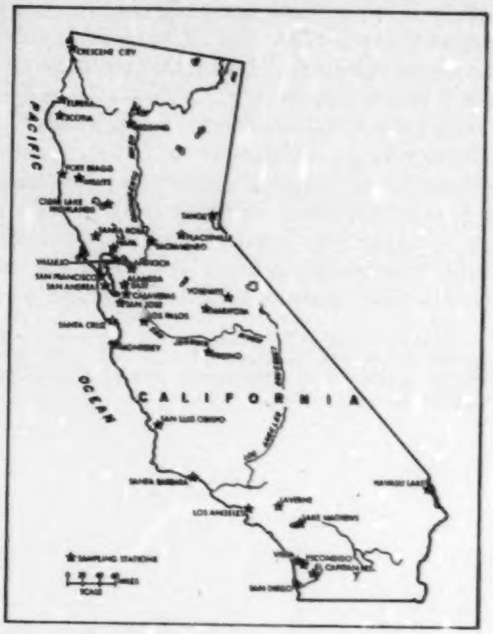

FIGURE 1.—CALIFORNIA SURFACE WATER SAMPLING STATIONS

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[1] Data from 'Radiological Health News," Vol. 3 No. 3, July, 1964, State of California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

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TABLE 1.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, JANUARY–JUNE 1964

[Concentrations in pc/liter]

Sampling station	January	February	March	April	May	June
Antioch	[a]4	[a]2	[a]23	97	36	74
Clearlake Highlands	[a]0	[b]—	[a]8	[a]25	—	88
Crescent City	[a]3	[a]0	[a]0	[a]	[a]8	44
Escondido	[a]6	[a]15	25	[a]24	30	29
Eureka	[a]5	[a]6	[a]15	47	[a]9	
Fort Bragg	—	—	—	40	[a]14	2
Fresno:						
Lake Millerton	[a]15	25	36	30	32	70
Mariposa	[a]13	[a]19	[a]12	108	88	36
Metropolitan Water District of Southern California:						
Lake Havasu	30	—	[a]17	—	[a]	19
Lake Matthews	36	[a]10	[a]19	[a]12	30	[a]12
Monterey	[a]16	[a]13	[a]0	50	[a]9	[a]11
Napa	[a]15	[a]1	[a]6	—	38	[a]20
North Marin Water District	[a]24	[a]9	[a]26	56	69	47
Oroville:						
Wyandotte Irrigation District	—	—	24	163	—	[a]25
California Water Service	—	7	—	—	27	—
Placerville	30	—	[a]13	—	[illegible]	71
Redding	[a]15	[a]0	[a]6	55	38	48
Sacramento	[a]18	[a]10	[a]5	30	34	
San Francisco:						
Alameda East	26	22	27	94	33	78
Brightside Weir	[a]2	[a]1	[a]0	36	[a]15	101
Calaveras Reservoir	[a]6	[a]0	[a]23	[a]18	50	25
Crystal Springs Line No. 1	[c][a]15	[c][a]14	[c][a]12	[a]42	[a]43	[a]30
Crystal Springs Line No. 2	[a]17	—	—	—	77	—
Hetch Hetchy Lombard Reservoir	[a]27	[a]9	[a]21	—	187	72
Moccasin	—	—	[c][a]15	[a]21	—	—
San Andreas Line No. 2	—	—	—	[a]58	[a]43	[a]51
San Jose	[a]0	[a]0	[a]0	[a]	39	—
San Luis Obispo	[a]16	[a]13	[a]0	—	—	—
Santa Barbara	—	—	—	42	[a]15	—
Santa Cruz	[a]18	30	[a]10	[a]17	[a]21	34
Santa Rosa	[a]8	[a]11	[a]16	72	[a]17	55
Scotia	[a]3	[a]14	[a]1	51	[a]15	[a]11
Tahoe City	[a]11	[a]9	—	55	32	—
Vallejo:						
Fleming Hill	53	36	32	61	49	—
Swanzy Reservoir	[a]21	[a]0	[a]5	59	23	—
Vista	—	—	—	—	—	27
Willits	35	30	[a]10	104	34	30
Yosemite	[a]1	32	22	72	54	143
Maximum	53	36	32	163	187	143
Minimum	0	0	0	12	8	2

[a] The counting rate of the sample is not equal to at least twice the 95 percent statistical counting error but the value reported is the best available estimate.

[b] Dash indicates no sample collected or analyzed.

[c] Average of more than one sample for the month.

vidual samples are composited in small glass petri dishes. The petri dishes are counted for 100 minutes using a gamma scintillation spectrometer. The quantities of the radionuclides of concern are calculated through the computer solution of eight simultaneous linear equations. Analysis is complicated by the presence of 0.51 Mev gamma radiation of unknown origin which may arise from a radionuclide emitting approximately this gamma energy or annihilation of a positron, where the positron resulted from either direct emission or "pair production".

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-dissolved solids in raw surface water in California from January through June 1964. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has in general been undetectable or very slight, alpha activity analyses are not presented. Little increase in the radioactivity level of surface water has been observed in spite of some increase in fallout.

TABLE 2.—RADIONUCLIDE CONCENTRATIONS IN CALIFORNIA SURFACE WATER, 1960–1963

[Concentrations in pc/liter]

Sampling station and date	Ba-La^{140}	K^{40}	Zn^{65}	Zr-Nb^{95}	Cs^{137}	0.51 Mev	I^{131}	Ce^{141}-Ce^{144}	Sr^{89}	Sr^{90}
Berkeley										
Jan. 61—June 61	•				b •	*1		*1,220		*0.2
July 61—Dec. 61				16		•			22	b
Jan. 62—June 62		•		•		•			*1	*0.1
July 62—Dec. 62	*56		*1	6	•	*1	•	•	3	0.4
Chula Vista										
Feb. 62—July 62		*1		*6		2		183	6	0.7
Aug. 62—Jan. 63		*1	*1	6	•			*1	*2	0.9
Crescent City										
July 60—Dec. 60	•	•	•	•	•	•	•	•		0.1
Jan. 61—June 61			•	•	•	•	•	•		0.1
July 61—Dec. 61		18		8		15		•	1	*0.1
Jan. 62—June 62	•	•	•	•	•	•	•	•	1	•
July 62—Dec. 62	•	*2		33	•			•	2	0.2
Jan. 63—June 63		•	•	3	•	*1	•	•	*1	0.1
Dos Palos										
July 60—Jan. 61	•	•	•	•	•	•	•	•		0.2
July 60—Oct. 61				32		6				0.5
Feb. 62—July 62				*3		*1			2	0.3
July 62—Jan. 63		*6	•	23	•	*1		2	8	0.4
Feb. 63—July 63									*3	0.7
El Centro										
Oct. 60—March 61		4				•				1.2
April 61—Sept. 61	•	•		99		*1			44	0.6
Oct. 61—March 62				3		2		•	48	*0.9
Eureka										
June 60—Nov. 60	•	•	•	•	•	•	•	•		
Jan. 61—June 61				63		•		*763		0.3
Aug. 61—Jan. 62				130		11		145	9	0.3
Jan. 62—July 62				98		3			187	3.6
Oct. 62—Dec. 62									•	0.1
Fresno, Lake Millerton										
July 60—Jan. 61	•	•	•	•	•	•	•	•		0.5
Feb. 61—June 61						20		•		0.2
Aug. 61—Jan. 62	•			44		1		206	3	0.3
Feb. 62—July 62				22		•		•	4	0.5
Aug. 62—Jan. 63				3		1			2	0.6
Feb. 63—July 63		*5		51	•	4		*1	*1	0.6
Los Angeles Dept. of Water and Power										
Jan. 61—July 61					•	•		*6		*0.3
July 61—Dec. 61		*13		92		*2			8	0.2
Jan. 62—June 62				6		1			5	0.4
Metropolitan Water District of Southern Calif.										
Jan. 61—June 61					•	•		•		0.5
July 61—Dec. 61		•		297	•	13		1,970	4	*0.1
Jan. 62—June 62		3		2		•			•	0.7
July 62—Dec. 62		*1	*1	152	•	6	•	*2	10	1.0
Jan. 63—June 63	•	•	•	6	•	1	•	19	5	1.2
Monterey										
July 61—Dec. 61		25		119		18		•	7	0.5
Jan. 62—June 62				15		*1		•	2	0.3
July 62—Jan. 63	•	•	*1	27	•	•		1	*1	0.3
Jan. 63—June 63	•	9	*2	•	1	•	•	3	•	*0.1
Napa										
Feb. 61—July 61						•		*11		0.4
Aug. 61—Jan. 62				2		2			22	0.2
Jan. 62—June 62		•		56	•	1		•	*4	0.2
June 62—Dec. 62	•	•	*1	*4	•	*1		1	3	•
Jan. 63—July 63	•	6	*9	53	2	11	•	5	*2	1.2
North Marin										
Jan. 61—July 61		11				•		•		*0.5
Aug. 61—Dec. 61		34		16		14		•	7	1.1
Jan. 62—July 62						2			5	0.8
July 62—Dec. 62	•	*12	*1	23	•	4		•	9	0.9
Jan. 63—July 63		*7	•	•	•	2	•	•	14	1.2
Redding										
Jan. 61—July 61						•		3		0.1
July 61—Dec. 61				9		•			4	0.3
Jan. 62—June 62		22		16		*2			4	0.3
July 62—Dec. 62				191		32		593	7	0.3
Jan. 63—June 63	•	*3		140	•	6		•	12	0.6
Sacramento										
Aug. 60—Feb. 61						•				0.3
March 61—Sept. 61						8				0.3
Sept. 61—Feb. 62		•		113		*1			39	0.6
March 62—Aug. 62		21		10		3			2	0.3
Sept. 62—Feb. 63	•	•		41	•	3		*1	3	0.5
Feb. 63—June 63	•	7	*2	2	1	3	•	2	*1	0.6
San Diego										
Nov. 60—April 61		7				•		91		0.8
Aug. 61—Dec. 61		*10		*10		*1		•	40	0.5
May 62—Oct. 62	•	*6	*1	46	•	*2	•	•	375	0.9

TABLE 2.—RADIONUCLIDE CONCENTRATIONS IN CALIFORNIA SURFACE WATER, 1960-1963—Continued

[Concentrations in pc/liter]

Sampling station and date	Ba-La^{140}	K^{40}	Zn^{65}	Zr-Nb^{95}	Cs^{137}	0.51 Mev	I^{131}	Ce^{141}-Ce^{144}	Sr^{89}	Sr^{90}
San Francisco										
Dec. 61—May 62		*9		2		2		*	8	0.4
San Luis Obispo										
May 61—Oct. 61	13			13		13		*		1.2
Jan 62—June 62		4		43		4		351	5	0.7
Santa Barbara										
June 61—Nov. 61		4		1		*		*		*0.7
Dec. 61—June 62				71		4		522	6	0.3
July 62—Nov. 62		*2	*	34	*	5		*2	5	0.6
Santa Cruz										
Nov. 61—April 62	*	*	*2	643	*	6	*	*	154	0.6
Santa Rosa										
July 61—Dec. 61				10		0		*	3	0.2
Jan. 62—June 62				1		*1			*	0.3
July 62—Dec. 62									*	1.1
Jan. 63—July 63		*6	*1	457	*	17	*	*	*	0.3
Vallejo										
Jan. 62—July 62						2			7	0.6
July 62—Dec. 62		*	*2	51	*	5		3	13	0.6
Jan. 63—July 63		47	[c]13	27	3	9	*	5	3	1.0
Yosemite										
May 61—[illegible] 61										2.0
July 61—Dec. 61				28		5		3,160		0.4
Nov. 61—April 62				8		*			4	0.2
Oct. 62—March 63	*	*	*	87	*	*		*	*3	0.9
Jan. 63—July 63	*	*	[c]2	16	1	6	*	2	*14	1.6

[a] Blank spaces indicate no analysis.

[b] Asterisks are used to indicate that the counting rate of the sample is not equal to at least twice the 0.95 error. The value reported is the best available estimate but is not statistically significant. An asterisk alone indicates no activity was detected.

[c] Mn^{54} instead of Zn^{65}.

Table 2 shows specific radionuclide concentrations in California surface waters for 1960-1963 bi-annually by stations.

Table 3 shows maximum radionuclide concentrations in California surface waters for the period 1960-1963. Related values of the International Committee on Radiological Protection Standards (*2*) for continuous population exposure are also shown. No standards are given for potassium-40 which occurs naturally. It is observed that none of the six-month composite raw surface water samples had specific radionuclide concentrations exceeding their respective MPC. For each radionuclide reported the minimum concentration observed was below detectable levels.

TABLE 3.—MAXIMUM OBSERVED RADIONUCLIDE CONCENTRATIONS IN CALIFORNIA SURFACE WATERS AND RELATIVE ICRP STANDARDS

Nuclide	Observed maximum (pc/liter)	MPC (pc/liter)
Ba-La^{140}	58	10,000
K^{40}	34	
Zn^{65}	2	10,000
Zr-Nb^{95}	643	20,000
Cs^{137}	3	2,000
I^{131}	0	670
Ce^{141}-Ce^{144}	3,160	3,300 (Ce^{144})
Sr^{89}	375	3,300
Sr^{90}	3.6	33

Previous coverage in *Radiological Health Data*:

Period	Issue
1961-June 1962	*April 1963*
July-December 1962	*September 1963*
January-June 1963	*March 1964*
July-December 1963	*September 1964*

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2. ICRP Report Number 2.

RADIOACTIVITY IN KENTUCKY WATERS, MAY 1963-JUNE 1964

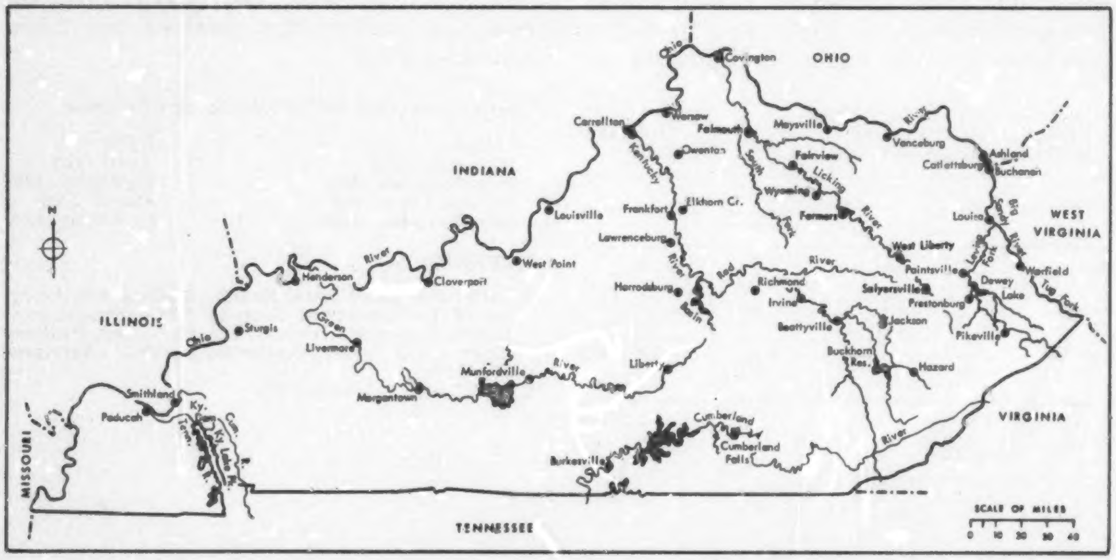
Radiological Health Program
Kentucky Department of Health

Radioactivity is usually present in all natural surface waters. Prior to 1942, any radioactive minerals in natural waters were there as a result of cosmic radiation and naturally occurring radionuclides in the earth's soil which had been taken up by these surface waters. After that time fallout from nuclear weapons testing and possibly radionuclides in waste water from the atomic industry operations could contribute some additional radioactivity. Sampling of surface waters in the Commonwealth of Kentucky is done for the purpose of establishing the levels of radioactivity presently existing and to establish any relationship between radioactivity levels and stream characteristics.

Surface water samples are collected from 48 sampling locations (figure 1) in seven river basins. General description of the basins in Kentucky can be found in "Surface Water Records of Kentucky" (*1*).

The suspended and dissolved solids in these samples are analyzed for gross alpha and beta radioactivity. Generally, no attempt has been made to determine the specific radionuclides present. Table 1 presents the results of the alpha and beta analyses of the water samples collected from May 1963 through June 1964.

The analytical method used for determining gross alpha and beta radioactivity is similar to that used by the PHS R. A. Taft Sanitary Engineering Center (*2*). One gallon samples are collected and shipped in polyethylene bottles. The volume of water analyzed is selected so that no more than 500 mg of either suspended or dissolved solids is present during counting. Generally, one liter of water is used. The sample is first filtered through a millipore filter Wattman 2/0 to separate the suspended and dissolved solids. The filter is then ashed. The filtrate is evaporated leaving the dissolved solids which are also subsequently dried.


OHIO
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Maysville
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Vanceburg
Ashland
Catlettsburg
Buchanan
Owenton
Fairview
Licking
South Fork
Wyoming
Farmers
River
Kentucky
Frankfort
Elkhorn Cr.
Louisville
Louisa
Big Sandy River
West Liberty
Levisa Fork
Lawrenceburg
West Point
Cloverport
River
Henderson
Red River
Paintsville
Warfield
Tug Fork
Harrodsburg
River Basin
Richmond
Irvine
Salyersville
Dewey Lake
Prestonburg
Beattyville
Jackson
Pikeville
Sturgis
Green
Livermore
Ohio
Munfordville
River
Liberty
Buckhorn Res.
Hazard
Morgantown
Smithland
Paducah
Ky. Dam
Tenn.
Cum.
Ky Lake R.
Cumberland
Cumberland Falls
Burkesville
River
SCALE OF MILES
0
10
20
30
40

Figure 1.—KENTUCKY SURFACE WATER SAMPLING STATIONS

TABLE 1.—AVERAGE GROSS RADIOACTIVITY IN KENTUCKY WATER, MAY 1963–JUNE 1964

[Concentrations in pc/liter]

River basin and location	Dates sampled	Beta			Alpha		
		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Big Sandy River							
Catlettsburg	6/5/64	6	9	15	<1	<1	<1
Buchanan	6/4/64	29	11	50	<1	<1	<1
Louisa: Louisa Fork	6/4/64	12	10	22	<1	<1	<1
Louisa: Tug Fork	6/4/64	32	9	41	<1	<1	<1
Warfield	6/5/64	4	7	11	<1	<1	<1
Paintsville	6/4/64	16	10	26	<1	<1	<1
Prestonsburg	6/4/64	3	15	18	<1	<1	<1
Dewey Lake	6/4/64	15	8	23	<1	<1	<1
Pikeville	6/4/64	3	7	10	<1	<1	<1
Cumberland River							
Burkesville	6/30/64	9	17	26	<1	<1	<1
Smithland	6/30/64	8	8	16	<1	<1	<1
Cumberland Falls	6/30/64	12	8	20	<1	<1	<1
Green River							
Liberty	5/13/64	2	9	11	<1	<1	<1
Munfordville	5/13/64	13	9	22	<1	<1	<1
Morgantown	5/13/64	7	10	17	<1	<1	<1
Livermore	5/13/64	10	12	22	<1	<1	<1
Henderson	5/13/64	4	15	19	<1	<1	<1
Kentucky River Basin							
Hazard	6/8/64	8	19	27	0	0	0
Jackson	6/8/64	15	20	35	0	<1	<1
Buckhorn Reservoir	6/8/64	7	21	28	<1	<1	<1
South Fork	6/8/64	21	25	46	<1	<1	<1
Beattyville	6/8/64	16	18	33	<1	<1	<1
Irvine	6/8/64	15	12	27	<1	<1	<1
Red River	6/8/64	17	17	34	<1	<1	<1
Richmond	6/8/64	26	13	39	<1	<1	<1
Harrodsburg	6/8/64	34	23	57	<1	0	<1
Lawrenceburg	6/8/64	20	22	42	<1	<1	<1
Frankfort	6/8/64	26	28	54	<1	0	<1
Elkhorn Creek	6/8/64	8	35	43	0	0	0
Owenton	6/8/64	43	25	68	<1	<1	<1
Carrolton	6/8/64	36	23	59	<1	<1	<1
Licking River							
Salyersville	8/18/63	6	12	18	<1	<1	<1
West Liberty	8/18/63	8	15	23	<1	<1	<1
Farmers	8/18/63	3	26	29	<1	<1	<1
Wyoming	8/18/63	5	19	24	<1	<1	<1
Fairview	8/18/63	14	31	45	<1	<1	<1
Falmouth	8/18/63	10	40	50	<1	<1	<1
Ohio River							
Ashland	7/31/63	3	14	17	1	1	2
Vanceburg	7/31/63	3	15	18	2	1	3
Maysville	7/31/63	3	14	17	1	0	1
Covington	7/31/63	3	14	17	1	0	1
Warsaw	7/31/63	3	12	15	0	1	1
Carrollton	7/31/63	3	14	17	2	0	2
Louisville	7/31/63	4	16	20	1	1	2
West Point	7/31/63	4	19	23	1	0	1
Cloverport	7/31/63	8	20	28	1	0	1
Henderson	7/31/63	15	18	33	1	1	2
Sturgis	7/31/63	5	21	26	1	1	2
Tennessee River							
Paducah	7/25/63	7	18	25	0	0	0
Kentucky Lake Park	7/25/63	4	16	20	<1	0	<1
Kentucky Dam	7/25/63	15	20	35	<1	<1	<1

The solid samples are counted for alpha and beta activity in a proportional counter.

Although the few samples collected at irregularly spaced time intervals provide only an indication of base-levels of radioactivity, general levels of gross beta radioactivity have been established for the 48 stations. In addition, some determination of gross alpha concentrations, half-life values, gamma energy spectra, and specific isotope concentrations have been made to establish the probable source of the higher concentrations of gross radioactivity. In specific instances, data on stream flow at the time of collection, and the quantity of suspended and dissolved solids was obtained.

From this initial sampling beginning in May 1963 and continuing through June 1964, the following may be concluded:

Small amounts of radioactivity are present in all sampled surface waters of Kentucky. Varying amounts of gross beta radioactivity were found in samples collected from all major streams during the period May 1963 to June

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1964. However, the concentration of radioactivity was well below the maximum permissible concentration limit for continuous exposure to the public as specified in the National Bureau of Standards Handbook 69 (*3*).

Radioactive waste from various industrial, educational, or medical isotope uses are not presently contributing noticeably to radioactivity levels in the streams.

The concentration of suspended radioactivity in surface waters is extremely variable. Suspended beta radioactivity concentrations in water samples collected throughout the State have ranged from less than 2 pc/liter to over 43 pc/liter. The dissolved beta radioactivity content of most streams appears relatively stable as compared to that in the suspended fraction.

Under normal conditions of streamflow the dissolved fraction accounts for essentially all the beta radioactivity. As flow increases the suspended radioactivity content increases for a short period. However, this relationship is not necessarily linear. This would appear to be related to an increase in total suspended solids resulting from increased turbulence.

REFERENCES

1. U. S. Geological Survey. Surface Water Records of Kentucky. U. S. Department of the Interior, District Engineer, Surface Water Branch, U. S. Geological Survey, 522 West Jefferson Street, Louisville 2, Kentucky.
2. Division of Radiological Health. Radionuclide Analyses of Environmental Samples R59–6, Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati 26, Ohio (November 16, 1959).
3. National Bureau of Standards. Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air and in Water for Occupational Exposure. Handbook 69, U. S. Government Printing Office, Washington, D. C. price $0.35.

Section IV—Other Data

RADIUM SOURCE SURVEYS IN KENTUCKY

Radiological Health Program
Kentucky Department of Health

Radium sources constitute a potential radiation hazard because of their ready availability, and because improper handling or storage may lead to loss or rupture (due to internal gas pressure). To protect the health of the citizens of Kentucky from these and other sources of ionizing radiation, regulations were adopted in October 1962 by the Kentucky State Department of Health requiring the registration of naturally-occurring or accelerator-produced radioactive materials and also radiation-producing machines. As a result of the implementation of these regulations, a total of 46 radium users were registered by December 1963. More than 80 percent of the sources registered were in the possession of hospitals or private physicians (see table 1).

TABLE 1.—NUMBERS OF RADIUM USERS

Type of facility	No. of facilities
Hospital	21
Private physician	16
Clinic	4
Academic institution	2
Industrial	2
Veterinarian	1

At the time of source registrations, each user was provided with a copy of the radiation regulations and notified on his registration certificate of the need for annual leak tests of each radium source. They were also provided with a suggested leak-test procedure.

The 46 registered users of radium in the State were surveyed during December 1963 and January 1964. A typical survey provided information regarding owner, type of facility, typical users, and information regarding radiological health procedures practiced at the facility. Results of the Statewide radium survey indicated that concern for radiological health aspects of radium storage and handling was justified (see table 2). The percentages of noncompliance items indicated in table 2, although high, would have been much higher except that State Health Department staff took time to correct many items of noncompliance at the time of the survey.

TABLE 2.—RADIUM SURVEY RESULTS

Items needing correction	Percent of total surveyed
No records of any type of survey performed	52
No type of leak test previously performed	46
Notice to employees not posted	37
Leakage found	35
Radium container not posted (warning signs)	35
Areas not posted (warning signs)	34
Personnel instruction or training not accomplished	22
Radiation surveys of any type not performed	22
Improper storage (unnecessary exposure)	10
No routine operating procedures	9
No records of personnel exposures (film badges, etc.)[1]	4

[1] Regulations require personnel monitoring where an individual is likely to receive in excess of 25 percent of the occupational exposure limit in any calendar quarter.

Discussions with the various users of radium indicated lack of respect for the significance of leaking sources of contamination therefrom. It appeared that most users were more concerned with the monetary value of the source rather than the potential radiation or contamination problem. Obviously, immediate action was necessary to check for possible leaking sources and contamination, and to provide some guidance and advice concerning proper storage and handling procedures. After this initial information was obtained, a survey kit was prepared consisting of an Eberline PAC–1SA alpha scintillation detector instrument, a Nuclear Chicago Model 2650 instrument with thin-wall and end-window G-M tubes, a box of paper tissue for obtaining smear samples, cotton-tipped sticks and alcohol to clean possibly contaminated detector probe faces, and a calibrated alpha check source of approximately 11,000 dpm (two-pi).

Direct measurements of radiation intensity and that of wipe samples from the sources were made. A wipe sample measuring greater than 200 cpm (with a 2-pi calibrated detector) of alpha activity or its equivalent 0.2 mrad/hr (by end window G-M) of alpha-beta-gamma activity was considered as the "alert level" for further leak testing. It was recommended that these further leak tests be performed on each source by health physics or radiological physics consultants. All collected wipe samples indicating potential contamination were returned to the laboratory and analyzed with internal gas-flow proportional counters to verify results of portable instrument monitoring.

Effectiveness of the survey technique was verified by the consultants finding leaking sources each time radiocontamination was at or above the "alert level." No "leaks" were found in those areas where no radiocontamina-
three typical surveys were as indicated in table
tion was found above "alert levels." Results of
3.

Test results verified that leaking sources could be readily detected by the use of portable instruments in a program of meticulous surveys of the storage area and storage container, and measurements of wipe-test samples from suspect areas.

Survey report and results forms were prepared not only to assure an orderly and complete recording of data but primarily to provide an immediate report to the user for suggested corrective action. Items of information required on the form were established to assure compliance with the Kentucky Department of Health radiation regulations. At the conclusion of each facility survey, the user was given a result form with the various items of noncompliance indicated and an explanation of what was required to correct the deficiencies. A copy of this form was returned to the Radiological Health Program records after it had been signed by the facility Radiation Safety Officer, or other responsible individual, at the conclusion of the survey discussion.

TABLE 3.—MEASURED CONTAMINATION IN THREE TYPICAL SURVEYS

Sample	Health Department results	Consultant results
	CASE #1	
Smear inside container	500 c/m (alpha)	—
Cotton from 24-hour storage	[a] —	3,000 c/m (alpha)
Cotton from 24-hour storage	—	[b] 0.4 mrad/hr (beta & gamma) with thin-wall G-M.
	CASE #2	
Smear inside container	No contamination	—
Cotton from 24-hour storage	—	No contamination
	CASE #3	
Smear inside container	1,000 c/m (alpha)	—
Direct measurement on lid of container	10,000 c/m (alpha)	—
Cotton from 24-hour storage	—	[c] 100,000 c/m with well-type gamma scintillator.

[a] Dash indicates no measurement done.

[b] The beta and gamma measurement would have been approximately 3 mrad/hr with an end-window G-M detector.

[c] The radioactivity on the sealed cotton from 24-hour closed test tube storage, after the source was removed, decayed with a half-life of approximately 10 hours.

The importance of radiological health surveys of radium users became apparent when a radiation physicist called attention to a leaking radium source that his organization had been given—property from the estate of a deceased physician. The leaking source was properly stored and measurements were made to assure insignificant contamination of equipment and property of the deceased physician. The leaking source and three other radium needles stored in the same container were brought to the Health Department Radiological Laboratory for further study and evaluation of proposed survey techniques and leak test procedures. At the conclusion of these tests, the leaking source was disposed of in an approved manner.

The success of this program was primarily due to the cooperation given survey teams, and interest and corrective action taken by the users in all cases. It is felt that the radium survey, and continuing program of radium source annual surveys, is one of the milestones in the Kentucky Radiological Health Program.

TABLE 4.—PORTABLE INSTRUMENT MEASUREMENTS

Needle No.	Cotton		Smear
	Beta + gamma [1] (mrad/hour)	Alpha + beta [2] (mrad/hour)	Alpha [3] (cpm)
1	[4] BG	BG	BG
2	BG	BG	BG
3	10	500 (off scale)	20,000
4	BG	2.5	150

[1] Determined by Geiger-Mueller detector.
[2] Determined by low-energy ion chamber.
[3] Determined by gas-flow internal proportional counter.
[4] BG indicates reading cannot be distinguished from background.

TABLE 5.—GAMMA SPECTRUM RESULTS

Gamma peak (MEV)	Relative peak activity		
	Needle	Wash water	Cotton
0.10	7.0	7.5	7.0
0.18	5.0	6.0	2.4
0.25	3.8	4.5	3.2
0.30	4.0	3.8	4.1
0.35	4.0	4.0	5.4
0.61	2.3	2.2	3.0
1.0	0.4	0.5	0.4
1.1	0.6	0.6	0.7
1.43	0.5	0.4	0.4
1.75	0.3	0.4	0.4

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors periodic reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity for 23 AEC installations have appeared periodically in *RHD* since November 1960. Following are reports for Argonne National Laboratory, Atomics International, and National Reactor Testing Station.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set forth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are essentially identical to those published in the Federal Register (*1*).

1. Argonne National Laboratory, January–June 1964

University of Chicago
Lemont, Illinois

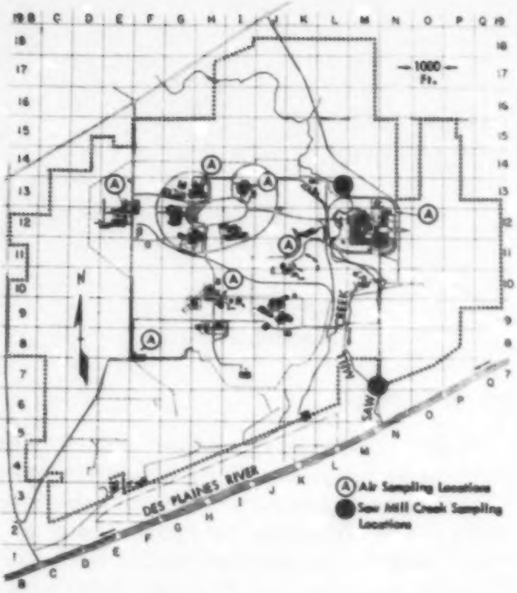
Air monitoring

Weekly continuous samples of airborne particulates for radioactivity measurements at 7 locations on the Argonne National Laboratory (ANL) site as shown in figure 1 and at 5 offsite locations at Aurora (west of ANL site), Wheaton (northwest), Hinsdale (northeast), Joliet (southwest), and Tinley Park (southwest). The quarterly averages of alpha, beta, and several nuclide concentrations are given in table 1. The radionuclide determinations were made from gamma spectra of monthly composites of the filters. The data show little difference between offsite and onsite measurements for alpha activity and most of the nuclides, in-

TABLE 1.—RADIOACTIVITY OF AIRBORNE PARTICULATES, ANL, JANUARY-JUNE 1964

[Average concentrations in pc/m³]

Type of analysis	Sampling location	January	February	March	April	May	June	Average
Alpha	On site Off-site	0.0032 0.0029	0.0036 0.0033	0.0039 0.0042	0.0042 0.0042	0.0051 0.0043	0.0039 0.0048	0.0040 0.0040
Beta	On site Off-site	0.9 0.9	1.0 1.0	1.4 1.4	1.5 1.5	2.0 2.1	1.8 2.1	1.4 1.5
Sb^{125}	On site Off-site	0.02 0.02	0.02 0.02	0.04 0.04	0.05 0.04	0.06 0.07	0.06 0.06	0.04 0.04
Ce^{144}	On site Off-site	0.34 0.33	0.32 0.48	0.63 0.72	0.80 0.69	1.10 0.99	0.85 1.06	0.74 0.75
Cs^{137}	On site Off-site	0.04 0.04	0.04 0.04	0.07 0.07	0.07 0.08	0.11 0.11	0.11 0.10	0.07 0.07
Ru^{103}	On site Off-site	<0.05 <0.05	<0.05 <0.05	0.06 0.06	0.05 0.05	0.06 0.08	0.04 0.03	0.04 0.04
$Ru\text{-}Rh^{106}$	On site Off-site	0.24 0.24	0.21 0.24	0.27 0.28	0.28 0.33	0.39 0.32	0.38 0.43	0.30 0.31
$Zr\text{-}Nb^{95}$	On site Off-site	0.09 0.08	0.07 0.07	0.09 0.09	0.08 0.08	0.09 0.09	0.07 0.07	0.08 0.08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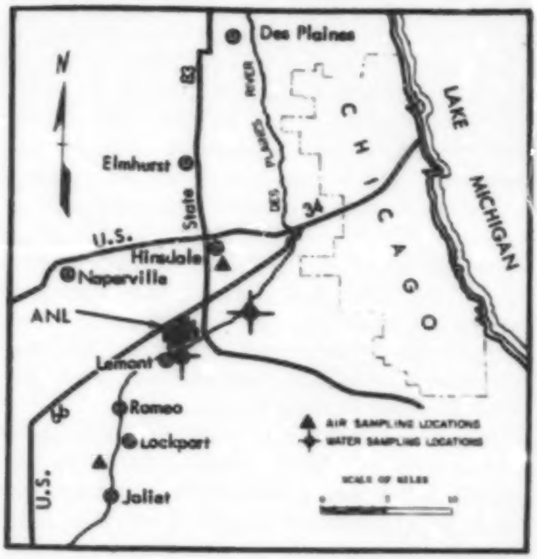
SAW MILL CREEK
DES PLAINES RIVER
Ⓐ Air Sampling Locations
● Saw Mill Creek Sampling Locations

FIGURE 1.—ONSITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

dicating that ANL does not contribute detectable quantities of these activities to the atmosphere. The average airborne beta activity during the first half of 1964 was approximately 1.5 pc/m³.

Water monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne Laboratory site and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sampling locations on Sawmill Creek and Des Plaines River are shown in figures 1 and 2, respectively.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Hinsdale
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ANL
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Romeo
Lockport
Joliet
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66
AIR SAMPLING LOCATIONS
WATER SAMPLING LOCATIONS
SCALE OF MILES
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10

FIGURE 2.—SITE LOCATION OF ARGONNE NATIONAL LABORATORY (INCLUDING SOME OFFSITE SAMPLING STATIONS)

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TABLE 2.—RADIOACTIVITY IN SAWMILL CREEK, ANL, JANUARY-JUNE 1964

[Average concentrations in pc/liter]

Type of analysis	Sampling location	January-June 1964		
		Maximum	Minimum	Average
Alpha emitters:				
Total alpha	Upstream	3.8	0.6	1.5
	Downstream	6.9	1.3	3.7
U-natural	Upstream	2.5	0.3	1.5
	Downstream	8.3	0.9	3.0
Pu^{239}	Upstream	<0.05	<0.05	<0.05
	Downstream	0.35	<0.05	0.10
Th^{232}	Upstream	<0.05	<0.05	<0.05
	Downstream	0.60	<0.05	0.13
Beta emitters:				
Total beta	Upstream	73	7	25
	Downstream	42	13	20
Co^{58}	Upstream	<5	<5	<5
	Downstream	62	<5	5
Co^{60}	Upstream	<3	<3	<3
	Downstream	40	<2	3
Sr^{89}	Upstream	<2	<2	<2
	Downstream	<2	<2	<2
Sr^{90}	Upstream	4.5	<0.5	3.4
	Downstream	5.8	<0.5	1.8
I^{131}	Upstream	<3	<3	<3
	Downstream	<3	<3	<3
Cs^{137}	Upstream	0.8	<0.5	0.4
	Downstream	11.3	<0.5	2.8
Ba^{140}	Upstream	<2	<2	<2
	Downstream	<2	<2	<2
$Th\text{-}Pa^{234}$	Upstream	2.0	0.6	1.2
	Downstream	6.0	0.5	1.9

On Sawmill Creek, weekly grab samples are collected upstream and 3 times a week samples are collected downstream from the waste water outfall. The upstream flow is roughly equal to the waste water flow, yielding a dilution factor of one-half. The data in table 2 show higher concentrations downstream and upstream. However, downstream concentrations were well below permissible concentration limits.

Weekly grab samples are collected from the Des Plaines River upstream and downstream from its junction with Sawmill Creek. The results indicate that the dilution factor of the Des Plaines River is so large that the radioactivity contribution from ANL is not detectable.

Recent coverage in *Radiological Health Data*:

Period	Issue
Third and fourth quarters 1960	*July 1961*
First and second quarters 1961	*December 1961*
Third and fourth quarters 1961	*May 1962*
1962	*May 1963*
1963	*August 1964*

REFERENCE

1. U.S. Atomic Energy Commission. Rules and regulations, standards for protection against radiation. Federal Register. Title 10, Part 20, Appendix B, Table 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

2. Atomics International
January–June 1964

Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, operates the Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) at Canoga Park, California, under contract with the Atomic Energy Commission. The company designs, develops, and constructs nuclear reactors for control stations, compact power plants, and medical, industrial, and scientific applications. Locations of the facilities are shown in figure 3.

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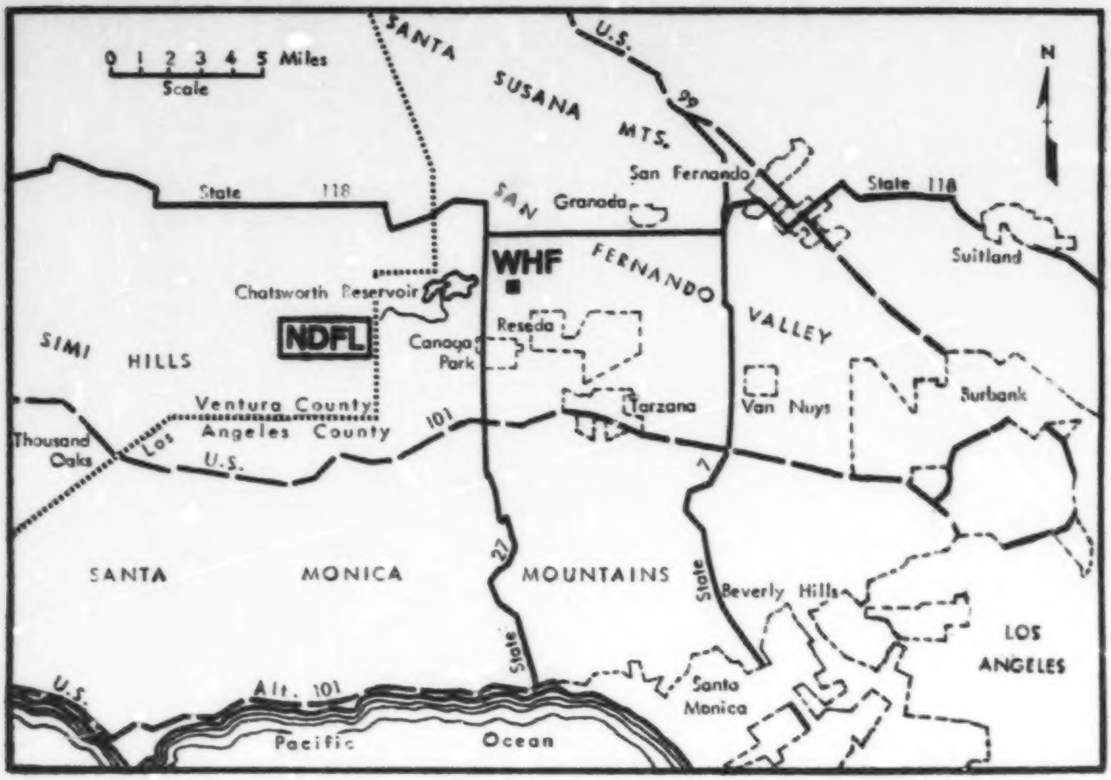
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Canoga Park
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SIMI HILLS
Tarzana
Van Nuys
Burbank
Ventura County
Los Angeles County
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State
State
SANTA MONICA MOUNTAINS
Beverly Hills
LOS ANGELES
U.S.
Alt. 101
Santa Monica
Pacific Ocean

Figure 3.—ATOMICS INTERNATIONAL FACILITIES AND VICINITY

The NDFL facilities include a 20-megawatt sodium reactor experiment (SRE) power reactor; several smaller experimental reactor facilities such as critical facilities, Systems for Nuclear Auxiliary Power (SNAP) reactor, shield test facilities, and others; and extensive rolling and fuel fabrication operations. The WHF is primarily an administrative building, but a small amount of fuel fabrication is conducted there. For this reason, the WHF area is included in the environmental monitoring.

Environmental monitoring is conducted at WHF and NDFL to test the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design. Surface soil, vegetation, water and air samples are surveyed periodically.

Air monitoring

Environmental air sampling is conducted continuously at the WHF and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a stationary filter tape which is automatically changed at the end of each sampling period. The filter tape is removed, allowed to decay for 72 hours, and counted in an automatic proportional counting system. The volume of atypical daily air sample is approximately 21 cubic meters. Averages for beta-gamma activity in airborne particulates are given in table 3.

Water samples

Processed water at the NDFL is obtained from wells and stored in 50,000 gallon tanks. Monthly samples are collected from these wells (see table 4). Potable water is obtained in bottles delivered to the site and is, therefore, not analyzed. Process water is drawn from the wells into one-liter polyethylene bottles for transfer to the laboratory. Water samples from the lake surface and supply inlet of Chatsworth

TABLE 3.—AIRBORNE PARTICULATE RADIOACTIVITY DATA

[activity in pc/m³]

Site	1963		First half 1964	
	Number of samples	Average concentration	Number of samples	Average concentration
Headquarters	360	6.6	182	2.0
NDFL	292	4.7	69	1.9

TABLE 4.—WELL WATER MONITORING, NDFL

[pc/liter]

Activity	1963		First half 1964	
	Number of samples	Average	Number of samples	Average
α	24	ᵃ0.18	11	ᵃ0.12
β, γ	24	7.0	11	ᵃ4.7

ᵃ Rounded from range of values originally reported.

Reservoir are similarly obtained (see table 5). In some cases the average concentration is presented as a range. The range occurs when one or more of the samples analyzed contains an undetectable amount of radioactivity.

TABLE 5.—CHATSWORTH RESERVOIR WATER SAMPLING

[pc/liter]

Sample	Activity	1963		First half 1964	
		Number of samples	Average	Number of samples	Average
Lake surface	α	[illegible]	0.84	12	0.60
	β, γ	[illegible]	[illegible]	12	12.6
Supply inlet	α	[illegible]	[illegible]	6	ᵃ0.41
	β, γ	[illegible]	[illegible]	6	10.

ᵃ Rounded from [illegible].

In the la[illegible] of water are evaporated to [illegible]allizing dishes at approximately 9[illegible] [illegible] residue salts are transferred into stainless steel planchets, wetted to produce an even sample distribution, redried under infra-red lamps, and counted in an automatic proportional counting system.

Soil and vegetation samples

Soil and vegetation are sampled monthly at 51 locations. Thirteen sampling stations are located within the boundaries of Atomics International and are designated as on site stations. The remaining 38 stations are located within a 0-mile radius of Atomics International and are referred to as off-site stations. Several of the off-site stations are located at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power.

Surface soil samples range from decomposed granite to clay and loam and are collected from the top half-inch layer of ground surface. The samples are placed in plastic containers and sent to the laboratory. Sample preparation consists of ashing in a muffle furnace at 500°C. for approximately eight hours, cooling, and sieving to obtain uniform particles for counting. One-gram aliquots of the soil are put in stainless steel planchets, wetted with acetone, redried, and counted in an automatic proportional counting system. Alpha and beta-gamma activities of soil samples are given in table 6.

TABLE 6.—SOIL RADIOACTIVITY

[pc/g]

Area	Activity	1963		First half 1964	
		Number of samples	Average	Number of samples	Average
On-site	α	156	ᵃ0.42	74	ᵃ0.35
	β-γ	156	45	74	35
Off-site	α	455	ᵃ0.40	221	ᵃ0.32
	β-γ	455	42	221	33

ᵃ Rounded from range of values originally reported.

Vegetation samples obtained in the field at each station are generally sunflower or wild tobacco plant leaves. At the laboratory the leaves are stripped from the plant and washed to remove foreign matter. The vegetation, after a distilled water rinse, is ashed in a muffle furnace at 500°C. for approximately eight hours, producing a completely oxidized ash of uniform density. Three-hundred milligram aliquots of ground ash are used for counting in an automatic proportional counting system. Vegetation data are shown in table 7.

TABLE 7.—RADIOACTIVITY IN VEGETATION

[pc/gm ash]

Area	Activity	1963		First half 1964	
		Number of samples	Average	Number of samples	Average
On-site	α	156	ᵃ0.44	76	ᵃ0.39
	β-γ	156	465	76	247
Off-site	α	456	ᵃ0.37	227	ᵃ0.39
	β-γ	456	358	227	231

ᵃ Rounded from range of values originally reported.

Previous coverage in *Radiological Health Data*:

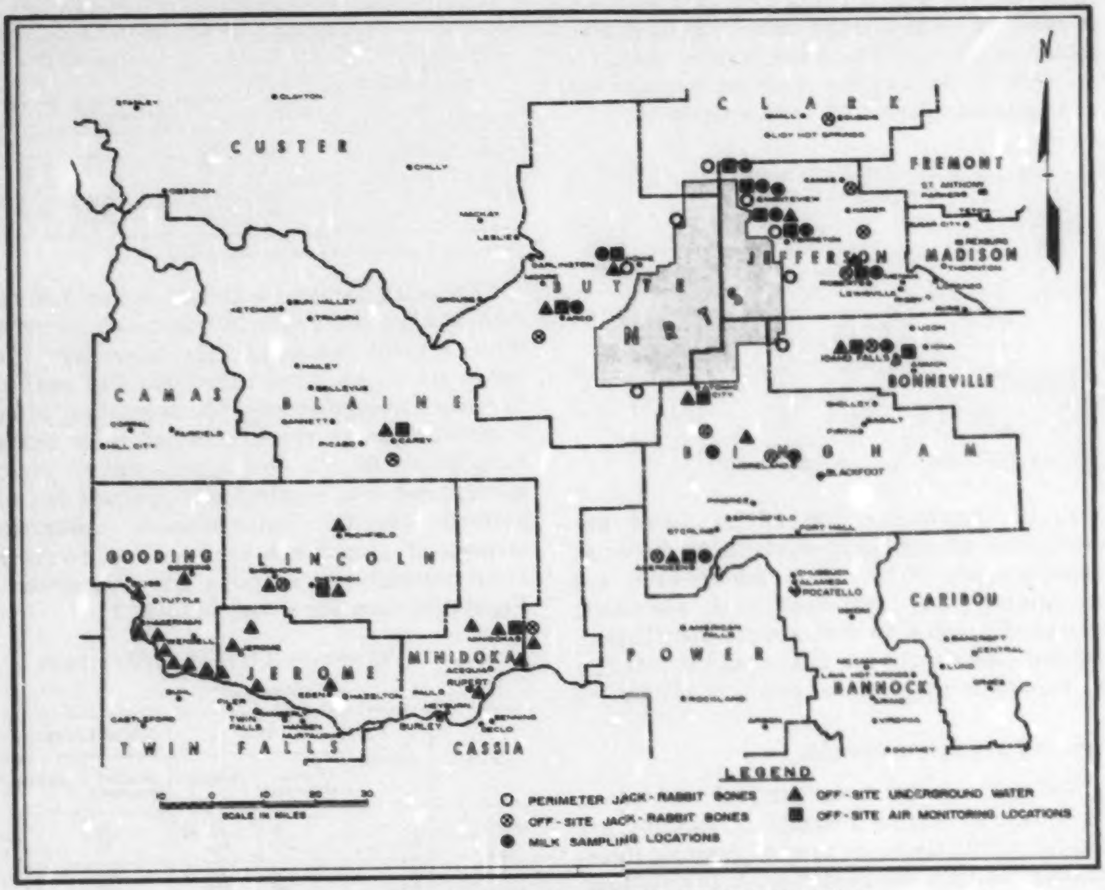
Period	Issue
1960 and First and Second quarters 1961	*December 1961*
Third and Fourth quarters 1961	*August 1962*
Calendar Year 1962	*November 1963*
Calendar Year 1963	*September 1964*

3. National Reactor Testing Station January–June 1964

Health and Safety Division
Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located about 20 miles from Idaho Falls, Idaho, in a very remote area which in a large measure permits controlled releases of radioactivity from the projects with minimum risk to the environs.

Responsibility for holding the environmental radioactivity levels at the station below the Radiation Protection Guides (RPG) recommended by the Federal Radiation Council (FRC) lies with the Atomic Energy Commission. One of the safeguards employed is a monitoring program. Descriptions of the monitoring network procedures have been presented earlier (see previous coverage). Beginning in January 1964, air data was reported by a radiation telemitry system while the former dual filter system continued in operation to obtain comparative data. The new system includes data from ion chambers and results of G-M counts from filter paper tapes. Quarterly environmental monitoring results in addition to averages for January to June 1964, are shown in table 8. Sampling locations at NRTS can be seen in figure 4.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CAMAS
BLAINE
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POWER
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SCALE IN MILES
LEGEND
○ PERIMETER JACK-RABBIT BONES
⊗ OFF-SITE JACK-RABBIT BONES
● MILK SAMPLING LOCATIONS
▲ OFF-SITE UNDERGROUND WATER
■ OFF-SITE AIR MONITORING LOCATIONS

FIGURE 4.—ENVIRONMENTAL MONITORING STATIONS

TABLE 8.—ENVIRONMENTAL MONITORING PROGRAM DATA, NRTS, JANUARY-JUNE 1964

Type of sample and units	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum activity of single sample	Average activity per sample
Off-site underground water (pc/liter)	32	semi-annual	alpha	3	9	<4
			beta	6	20	<10
On-site production well water (pc/liter)	22	two weeks	alpha	3	7	<4
			beta	6	100	<20
Off-site air (pc/m³)	15	continuous	beta-gamma	1.6	19	<1.6
	15		iodine-131	3.6	40	<3.6
Off-site milk (pc/liter)	14	monthly	iodine-131	20	<20	<20
	11	monthly	strontium-90	1.5	44	28
Off-site area monitoring badges (mrem)	14	monthly	beta	10	10	<60
			gamma	10	25	<60

Previous coverage in *Radiological Health Data*:

Period	Issue
1959 and first quarter 1960	*November 1960*
Second quarter 1960	*February 1961*
Third and fourth quarters 1960	*May 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*June 1962*
1962	*June 1963*
1963	*September 1964*

REPORTED NUCLEAR DETONATIONS, FEBRUARY 1965

During the month of February three United States nuclear tests were announced by the Atomic Energy Commission.

The February 4, 16, and 18 tests were conducted underground at the Nevada Test Site. All were of low-yield (less than 20 kilotons).

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